

THE UNITED STATES, CHINA,  
AND THE FIGHT FOR GLOBAL LEADERSHIP:  
BUILDING A U.S. NATIONAL SCIENCE  
AND TECHNOLOGY STRATEGY

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HEARING  
BEFORE THE  
COMMITTEE ON SCIENCE, SPACE,  
AND TECHNOLOGY  
OF THE  
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**TUESDAY, FEBRUARY 28, 2023**

HOUSE OF REPRESENTATIVES,  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,  
*Washington, D.C.*

The Committee met, pursuant to notice, at 10 a.m., in room 2318, Rayburn House Office Building, Hon. Frank Lucas [Chairman of the Committee] presiding.

U.S. HOUSE OF REPRESENTATIVES  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

*“The United States, China and the Fight for Global Leadership: Building a  
U.S. National Science and Technology Strategy”*

Tuesday, February 28, 2023  
10:00 a.m. – 12:00 p.m.  
2318 Rayburn House Office Building

**Purpose**

On Tuesday, February 28, 2023, the Science, Space, and Technology Committee will hold a hearing to examine the current state of the United States’ science and technology enterprise and how it is impacting our global leadership, as well as threats to that leadership from the Chinese Communist Party (CCP). This hearing will examine the CCP’s attempts to surpass U.S. scientific leadership and the economic and national security implications that it has for America. It will also serve as an opportunity to discuss and identify key objectives for a U.S. National Science and Technology Strategy and quadrennial review to ensure the United States’ continued growth and competitiveness.

- **Dr. Kelvin Droegemeier**, Regents’ Professor of Meteorology and Weathernews, Chair Emeritus Roger and Sherry Teigen Presidential Professor, University of Oklahoma and Former Director, White House Office of Science and Technology Policy
- **Ms. Deborah Wince-Smith**, President and CEO, Council on Competitiveness
- **Dr. Kim Budil**, Director, Lawrence Livermore National Laboratory
- **Mr. Klon Kitchen**, Senior Fellow, American Enterprise Institute

**Overarching Questions**

- What is the current state of U.S. leadership in science and technology (S&T), and what is the outlook for continued leadership, particularly in areas of S&T that will help drive economic competitiveness and national security in the coming decade? Why is it important for the U.S. to maintain leading capabilities in both fundamental research and technology development, and what are the consequences of loss of leadership, especially to China?
- What makes the U.S. S&T ecosystem of government, academia and industry unique in the world, and how can we continue to use that system to our competitive advantage?
- What are the benefits to having a National Science and Technology Strategy? What are the key characteristics of a National Science and Technology Strategy that will ensure it is adopted and utilized by the U.S. S&T ecosystem and leads to the public and private sectors working together to ensure America’s S&T dominance?

## NATIONAL S&T STRATEGY AND QUADRENNIAL REVIEW

First proposed in Chairman Lucas' "Securing Leadership in Science and Technology Act" (SALSTA) in 2019, the CHIPS and Science Act of 2022<sup>1</sup> directed the Office of Science and Technology Policy (OSTP) to develop a 4-year comprehensive national S&T strategy, primarily focused on economic security, and consistent with other relevant federal strategies such as the National Defense Strategy or National Security Strategy. Additionally, the legislation requires OSTP to conduct a quadrennial review of the science and technology enterprise. This quadrennial review will serve as a comprehensive examination of U.S. science capacity and make informed policy and investment recommendations in areas such as industrial innovation, STEM workforce, tech transfer, regional innovation, and U.S. research leadership.

These strategies will not only provide useful context for policymakers to shape national priorities, but also inform the strategic framework for making federal investment decisions – a tactic many countries already employ. A successful strategy will balance competing ideas from various stakeholders while also identifying ways to ensure buy-in from public and private entities. Both the quadrennial review and the S&T strategy will serve as a tool for furthering U.S. leadership in science and technology.

## U.S. RESEARCH & INNOVATION LANDSCAPE

### *Background*

Since the 18<sup>th</sup> century, the relationship in the United States between science, technology, research and development has been a close one, as Americans created a decentralized system for the advancement of scientific innovation by combining federal government backing of basic research with university and privately funded research. For decades, that system has helped America lead the world in science and technology innovation, driving economic growth, addressing national priorities, and improving the health and quality of life of Americans.

More than half of the economic GDP growth in the United States during the first half of the twentieth century has been due to scientific and technological advancements.<sup>2</sup> A primary driver of future economic growth and job creation will be innovation that is made possible through advances in science and engineering.<sup>3</sup> Scientific discovery has also allowed the U.S. to maintain strategic military advantages. The U.S. investment in research and innovation allowed the U.S. to become the strongest economy in the world.<sup>4</sup> The federal government supports scientific and technological advancement directly by funding and performing R&D and indirectly by creating and maintaining policies that encourage private sector efforts.

Research is generally categorized as either "basic" or "applied," with the former seeking to produce new knowledge without any specific application in mind, and the latter focusing on addressing a more specific problem or need. According to the American Academy of Arts and Sciences, basic research lies behind every new product brought to market, every new medical device or drug, every new defense and space technology, and many innovative business practices.<sup>5</sup>

<sup>1</sup> [P.L. 117-167](#)

<sup>2</sup> R.M. Solow, Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, 39: 312-320, 1957.

<sup>3</sup> Vest, C.M., 2010, *Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5*, National Academy of Sciences at <https://www.nap.edu/read/12999/chapter/2>

<sup>4</sup> Tripp, Simon, 2013, *The Impact of Genomics on the U.S. Economy*, Batelle Memorial Institute, at <https://www.unitedformedicalresearch.org/wp-content/uploads/2013/06/The-Impact-of-Genomics-on-the-US-Economy.pdf>

<sup>5</sup> Restoring the Foundation: The Vital Role of Research in Preserving the American Dream. (n.d.). Retrieved from [https://www.amacad.org/sites/default/files/publication/downloads/AmericanAcad\\_RestoringtheFoundation.pdf](https://www.amacad.org/sites/default/files/publication/downloads/AmericanAcad_RestoringtheFoundation.pdf)

### *U.S. R&D Expenditures*

The most recent estimate of total U.S. research and development (R&D) spending was \$720.9 billion in 2020,<sup>6</sup> an amount greater than any other country and more than a quarter of the global total. While the private sector funds and performs the majority of U.S. R&D, the Federal government has been the leading source of support for basic research, often funding R&D in areas that industry lacks strong incentives to fund as well as areas of critical importance to national security. In 2019, basic research activities comprised \$102.9 billion (15%) of the total of U.S. R&D expenditures, followed by applied research at \$132.0 billion (20%) and \$432.0 billion (65%) for experimental development.<sup>7</sup>

The business sector has accounted for most of the growth in total U.S. R&D over the last decade. According to the National Center for Science and Engineering Statistics (NCSES) at the National Science Foundation (NSF), in 2010, businesses invested \$248 billion in R&D, compared to \$127 billion by the Federal government. In 2019, these numbers rose to \$464 billion and \$139 billion, respectively, which means the business sector now accounts for 73 percent of all U.S. R&D. The remainder of R&D funding comes from states, foundations, nonprofit organizations, and universities' institutional funds.

### *Global R&D Expenditures and U.S. Competitiveness*

The global total of R&D expenditures continues to rise at a substantial pace. The NCSES's latest estimate puts the worldwide total at \$2.4 trillion (current PPP dollars) in 2019.<sup>8</sup> In 2010, it was estimated at \$1.416 trillion, and in 2000, the estimate was \$722 billion. This nearly threefold expansion over nearly two decades reflects, in part, the escalating knowledge intensity of economic competition among the world's nations—as well their individual desires to harness advances in science and technology to improve their own economies and indicators of their societal well-being.<sup>9</sup> Asian countries, most notably China, have heavily contributed to the overall increase in worldwide R&D expenditures – a notable shift in the global concentration of R&D performance from the United States and Europe to East-Southeast Asia and South Asia.<sup>10</sup>

While the U.S. remains the largest R&D performer, its share of global R&D has declined substantially. From 1960 to 2020, the U.S. share of global R&D fell from 69 percent to 31 percent.<sup>11</sup> This decline resulted from rapid growth in public and private R&D spending by other nations, even as U.S. R&D expenditures since 1960 have grown more than 37 times in current dollars. However, China has rapidly become the second largest R&D performer, accounting for 24.8 percent of global R&D in 2020, up from 4.9 percent in 2000.<sup>12</sup>

China poses an especially formidable and growing strategic challenge. The CCP has exhibited dramatic growth in its investment in R&D, 13% in 2019 alone and nearly tripling between 2000 and 2019.<sup>13</sup> The CCP is pursuing aggressive plans to dominate the next generation of technology. National policies—such

<sup>6</sup> U.S. Congressional Research Service. *Global Research and Development Expenditures: Fact Sheet* (R44283; September 14, 2022), by John F. Sargent, Jr. Accessed February 21, 2023 at <https://crsreports.congress.gov/product/pdf/R/R44283>

<sup>7</sup> National Science Board, National Science Foundation. 2022. *Research and Development: U.S. Trends and International Comparisons. Science and Engineering Indicators 2022*. NSB-2022-5. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20225/>.

<sup>8</sup> *Id.*

<sup>9</sup> National Science Board, National Science Foundation. 2020. *Science and Engineering Indicators 2020: The State of U.S. Science and Engineering*. NSB-2020-1. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20201/>.

<sup>10</sup> National Science Board, *supra* note 6.

<sup>11</sup> U.S. Congressional Research Service, *supra* note 5.

<sup>12</sup> *Id.*

<sup>13</sup> Hourihan, M. & Zimmerman, A. (2022, January 19). Some Key Takeaways From NSF's "State of the Science" Report. Retrieved February 23, 2023. Available at <https://www.aaas.org/news/some-key-takeaways-nsfs-new-state-science-report>.

as the Made in China 2025 Plan and 1000 Talents program—are concerted efforts to cultivate indigenous technological innovation, backed by commitments for hundreds of billions of dollars in investment. However, the R&D priorities of the U.S. and the CCP are very different. In the United States, 17 percent of R&D expenditures goes towards funding basic research compared to only 6 percent in China. The CCP is much more focused on R&D development which accounts for 84 percent of their R&D portfolio compared with only 64 percent in the United States.<sup>14</sup> This focus on technology development has resulted in China surpassing the U.S. in 2011 to become the leader in knowledge- and technology- intensive manufacturing.<sup>15</sup>

#### *Federally Funded Research and Development Centers (FFRDCs)*

FFRDCs, which includes the Department of Energy National Laboratories, play an important role in our R&D enterprise, supporting large-scale, long-term R&D, including through the construction of major user facilities in key technology areas, including computing and biotechnology. The work conducted at the FFRDCs covers a wide spectrum of applications as well, from truly open basic research to highly classified national security projects. Some of the fastest supercomputers in the world are housed in the DOE National Laboratory Complex, providing insight into some of today's most pressing scientific questions. Advanced light sources at the labs are also providing discoveries that have broad industrial impacts in the fields of molecular science and advanced materials research. FFRDCs are privately operated R&D organizations that are exclusively or substantially funded by the federal government. In 2021, the federal government funded \$24.5 billion (98.4%) of R&D expenditures across 43 FFRDCs.<sup>16</sup> Because they are distributed across the country, including states and regions that are generally not among the highest in research and innovation capacity, they also serve an important role in local economic development and in providing STEM education and research experiences to students who might otherwise not have such access.

#### *University R&D Investment*

The United States has long been home to many of the world's leading research institutions. In 2019, U.S. universities performed a total of \$83.7 billion in R&D from all sources, including \$39.5 billion in Federally funded R&D. The share of academic R&D funded by Federal agencies declined from 60 percent in 2010 to 50 percent in 2019.<sup>17</sup> Other sources of funding include institutional funds, industry, and foundations. University research advances foundational knowledge in science and technology. Universities are also the source of thousands of spin-off companies that contribute to regional economic development and job creation. Such spin-offs are primarily clustered in geographic proximity to the university.

#### *Public-Private Partnerships*

There are many partnerships between the government (including national labs), universities, and the private sector, and the Committee on Science, Space, and Technology often explores the nature of those partnership models - what works, what can be expanded, and what new models may be viable. Such partnerships require a sustained commitment by all parties and new ways of partnering as new challenges and opportunities arise. They also require new thinking as to who the partners must include. There is increasing focus on bringing to the table non-traditional partners, including local governments and community organizations, civil society organizations, labor organizations, and others who might be users of, or might be affected by, the research being carried out.

<sup>14</sup> *Id.*

<sup>15</sup> *Id.*

<sup>16</sup> Gibbons MT; National Center for Science and Engineering Statistics (NCSES). 2022. *Federally Funded R&D Centers Report 6% Increase in R&D Spending in FY 2021*. NSF 22-334. Alexandria, VA: National Science Foundation. Available at <https://ncses.nsf.gov/pubs/nsf22334/>.

<sup>17</sup> National Science Board, *supra* note 6.

Beyond the overall investment figures, key policy issues and challenges present barriers to capitalizing on R&D expenditures. For instance, some observers have described a “valley of death” between basic research conducted at U.S. universities and the commercialization activities typically carried out by industry, since universities generally do not have the means of production necessary to take the results of initial research and generate marketable products. According to the American Academy of Arts and Sciences, the pace of American innovation—translation of discoveries and inventions from laboratory research to products must accelerate for the U.S. to remain competitive.<sup>18</sup> Closer cooperation among industry, government, and academia could increase technology transfer, stimulate innovation, lead to new products and processes, and expand markets.<sup>19</sup>

### *U.S. STEM Workforce*

Since World War II, the United States has benefitted from the social, economic, health, and military advances made possible, in part, by a highly skilled STEM workforce. Today, a wide range of U.S. occupations in STEM and non-STEM fields either require or benefit from workers with STEM skills and knowledge. Science and technology skills will continue to be as important in the future as they were in the past, if not more so. As such, widespread STEM literacy, as well as specific STEM expertise, are critical human capital competencies for the 21st century. The United States is falling behind other nations in the production of total STEM degrees after having been the world leader in educational attainment for several decades after World War II.<sup>20</sup>

To remain competitive, the U.S. needs flexible STEM-capable workers at every education level. The need for U.S. workers with STEM skills is heightened in today’s global economy and is projected to increase in the future. According to the Science and Engineering Indicators Report of 2022, the STEM workforce in the United States—made up of occupations like software developers, computer system analysts, chemists, mathematicians, economists, research scientists, STEM teachers and engineers—has grown rapidly and now constitutes 23% (about 36 million) of all U.S. jobs.<sup>21</sup> This includes 17 million workers that comprise the skilled technical workforce who use science and engineering expertise and technical knowledge but do not hold bachelor’s degrees.<sup>22</sup>

The National Science Board, in its Vision 2030 report, has concluded that to maintain its global leadership in science and technology research and development, the United States must continue to cultivate a diverse workforce by expanding domestic talent and continuing to attract and retain global talent. The pressure on the U.S. talent pipeline is heightened by the rapid increase in the CCP’s STEM workforce. According to the most recent estimates, the United States awarded nearly 1.1 million S&E first university degrees in 2019, broadly equivalent to a bachelor’s degree. China produced 1.8 million S&E first university degrees<sup>23</sup>, growing from 359,000 degrees in 2000.<sup>24</sup>

In addition, it has been well documented that the CCP is making a deliberate effort to recruit top foreign talent, particularly from U.S. universities, industry and the federal government. The Department of Energy warned that talent programs were offering scientists at U.S. national labs hundreds of thousands, and in

<sup>18</sup> Moore, J., & Wilson, I. (2021, January 04). *Decades of basic research paved the way for today's Covid-19 vaccines*. Retrieved February 22, 2023, from <https://www.statnews.com/2021/01/05/basic-research-paved-way-for-warp-speed-covid-19-vaccines/>.

<sup>19</sup> Congressional Research Service, RL32076, *The Bayh-Dole Act: Selected Issues in Patent Policy and the Commercialization of Technology*, (Dec. 2012).

<sup>20</sup> Congressional Research Service. *Science, Technology, Engineering, and Mathematics (STEM) Education: An Overview*. CRS Report No. R45223, at <https://crsreports.congress.gov/product/pdf/R/R45223/4>.

<sup>21</sup> National Science Board, *supra* note 6.

<sup>22</sup> National Science Board, National Science Foundation. 2019. *The Skilled Technical Workforce: Crafting America's Science & Engineering Enterprise*. NSB-2019-23. Alexandria, VA. Available at <https://www.nsf.gov/nsb/publications/2019/nsb201923.pdf>.

<sup>23</sup> National Science Board, *supra* note 6.

<sup>24</sup> National Science Board, *supra* note 23.

some cases millions, of dollars to conduct research in China.<sup>25</sup> Federal investigators identified 23 U.S. academics and dozens of industry scientists with financial ties to China.<sup>26</sup> To address this threat, the House Science Committee worked to ensure the CHIPS and Science Act included a prohibition of federal employees participation in foreign talent programs and a prohibition for all federally funded research grantees from being a member or participating in a malign foreign talent program.

## CHALLENGES TO U.S. INNOVATION

### *Competition with China and U.S. Response*

The CCP has vowed to turn the nation into a self-reliant technology power.<sup>27</sup> China and the United States take different approaches to R&D. For instance, the CCP mandates the political and economic trajectory of the nation through the publication of Five Year Plans. In the 14<sup>th</sup> Five Year Plan, governing 2021 to 2025, President Xi encouraged basic research and discussed the need to fortify the national innovation system.<sup>28</sup> The CCP's Made in China 2025 plan<sup>29</sup> uses government subsidies, state owned enterprises, and intellectual property acquisition to transform China into one of the most powerful high-tech and manufacturing countries in the world.<sup>30</sup>

This top-down policy prescription differs from the United States, which employs mostly a decentralized bottom-up approach to innovation and R&D. While the American government certainly encourages the growth and development of the national innovation system, it by no means dictates precisely how this growth should occur; rather, the federal government largely allows academia and industry to drive this development, providing funding and regulation as necessary.<sup>31</sup> Through this approach, the U.S. has created a S&T ecosystem that fosters innovation, risk taking, and the discovery of new ideas.

But if the U.S. is to maintain its competitive edge in science and technology, the nation must coordinate across all public and private sectors to expand capacity, participation, and collaboration and allow for strategic investments in research and technology. This is a particularly urgent issue for the U.S. in emerging technology fields that will serve as the main sites for innovation and competitive advantage, and lead to unprecedented national security challenges in the 21<sup>st</sup> century.

## CRITICAL TECHNOLOGIES

**Artificial Intelligence (AI):** AI includes technologies that allow computers and other machines to learn from experience and complete tasks that have traditionally required human intelligence or reasoning. AI could be one of the most disruptive technologies of the 21<sup>st</sup> century and is advancing rapidly. On February 11, 2019, President Trump issued an Executive Order to launch the American AI Initiative, which directs federal agencies to develop AI R&D budgets to support their core missions.<sup>32</sup> Federal agencies are also

<sup>25</sup> Puko, T. & O'Keefe, K. *U.S. Targets Efforts by China, Others to Recruit Government Scientists*. 2019, June 10. Available at <https://www.wsj.com/articles/energy-department-bans-personnel-from-foreign-talent-recruitment-programs-11560182546>.

<sup>26</sup> Mervis, J. *Trial of Harvard chemist poses test for U.S. government's controversial China Initiative*. Science. (2021, December 2). Available at <https://www.science.org/content/article/trial-harvard-chemist-poses-test-u-s-government-s-controversial-china-initiative>.

<sup>27</sup> Lietzow, R., Ye, Q., and Tan, S., *A New Era of Chinese Technology and Innovation* at <https://china.ucsd.edu/opinion/post/a-new-era-of-chinese-technology-and-innovation.html>.

<sup>28</sup> McDonald, J., *China's leader vow to become self-reliant technology power* at <https://apnews.com/article/technology-beijing-xi-jinping-china-economy-d046181a106413621761248660d47479>

<sup>29</sup> *Made in China 2025' plan issued*. Retrieved March 31, 2021, from [http://english.www.gov.cn/policies/latest\\_releases/2015/05/19/content\\_281475110703534.htm](http://english.www.gov.cn/policies/latest_releases/2015/05/19/content_281475110703534.htm).

<sup>30</sup> McBride, J., & Chatzky, A. *Is 'made in CHINA 2025' a threat to global trade?* Retrieved March 31, 2021, from <https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade>.

<sup>31</sup> *Id.*

<sup>32</sup> E.O. 13859 of Feb 11, 2019. Available at <https://trumpwhitehouse.archives.gov/presidential-actions/executive-order->

directed to increase access to their resources to drive AI research by identifying high-priority federal data and models, improving public access to and the quality of federal AI data, and allocating high-performance and cloud computing resources to AI-related applications and R&D. In December 2020, Congress enacted the National Artificial Intelligence Initiative Act.<sup>33</sup> This bipartisan legislation, which was led by the House Science Committee, accelerated and coordinated Federal investments and new public-private partnerships in research, standards, and education in trustworthy artificial intelligence.

**Quantum Information Science (QIS):** Through developments in QIS, computers can handle new workloads and solve much more difficult challenges than traditional computers. In 2018, this Committee developed, and the President signed into law, the *National Quantum Initiative Act*<sup>34</sup>, which leverages the resources and expertise of U.S. government, industry, and academia to create a unified national quantum strategy that ensures the U.S. continues breakthroughs in QIS. President Trump also released the *National Strategic Overview for Quantum Information Science*<sup>35</sup> to guide Federal QIS actions, including the establishment of a Quantum Economic Development Consortium to build the QIS industrial ecosystem.

Since those initial actions, Congress has continued to take an active role in structuring critical R&D programs to account for the growing role of QIS. In 2020, Congress passed the National Defense Authorization Act for Fiscal Year 2020<sup>36</sup>, which extended QIS R&D directives to the Department of Defense and established QIS research centers to accelerate U.S. capabilities. Multiple bills have been filed to prevent exports of quantum technologies to China, with a particular focus on QIS computing.<sup>37 38 39</sup>

The country that harnesses the power of quantum technology will have a significant security and economic advantage. The race to reach operational quantum technologies in communications, encryption, and computing will be one of the most important technological efforts of the coming decade for the U.S.

**Advanced Manufacturing:** Advanced manufacturing technologies fundamentally alter and transform manufacturing capabilities, methods and practices. These new manufacturing technologies drive U.S. competitiveness by enabling improved productivity, the development of superior products, and has led to the formation of entirely new industries. President Trump developed a *National Strategic Plan on Advanced Manufacturing*<sup>40</sup> that focuses on expanding manufacturing employment and ensuring a resilient supply chain and strong manufacturing and defense industrial base.

**Fusion:** The fusion energy industry is experiencing a period of global renaissance. With the recent December announcement<sup>41</sup> from Lawrence Livermore National Laboratory that the National Ignition Facility has achieved ignition for the first time, the continued construction progress at the International Thermonuclear Experimental Reactor (ITER), and the rapid growth of multiple U.S. based startup companies, the field has never been busier. The Department of Energy has been prioritizing ways that the National Laboratory Complex can advance U.S. leadership in fusion energy sciences and assist commercial fusion companies with the challenges they are facing. This has been done through increases in

[maintaining-american-leadership-artificial-intelligence/](https://www.whitehouse.gov/wp-content/uploads/2020/10/2018-NSTC-National-Strategic-Overview-QIS.pdf).

<sup>33</sup> P.L. 116-283.

<sup>34</sup> P.L. 115-368.

<sup>35</sup> National Science & Technology Council. *National Strategic Overview for Quantum Information Science*. September 2018. Available at <https://www.quantum.gov/wp-content/uploads/2020/10/2018-NSTC-National-Strategic-Overview-QIS.pdf>

<sup>36</sup> P.L. 116-92.

<sup>37</sup> H.R. 3532, 116<sup>th</sup> Cong. (1<sup>st</sup> Sess. 2019).

<sup>38</sup> H.R. 704, 116<sup>th</sup> Cong. (1<sup>st</sup> Sess. 2019).

<sup>39</sup> H.R. 3407, 116<sup>th</sup> Cong. (1<sup>st</sup> Sess. 2019).

<sup>40</sup> National Science and Technology Council. *Strategy for American Leadership in Advanced Manufacturing*. October 2018. Available at <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf>.

<sup>41</sup> Lawrence Livermore National Laboratory. *National Ignition Facility achieves fusion ignition*. December 13, 2022. Available at <https://www.llnl.gov/news/national-ignition-facility-achieves-fusion-ignition>.

traditional grant-based funding and the creation of INFUSE, a program targeting the development of public-private partnerships for fusion. These fusion energy activities and others were recently authorized in the Energy Act of 2020<sup>42</sup> and the CHIPS and Science Act<sup>43</sup>.

## RESEARCH SECURITY

### *Background*

In recent years, several incidents have led to the concern that other countries are taking advantage of the openness of the academic research environment in the United States.<sup>44</sup> This sense of unfair competition is entwined with concerns about U.S. economic and national security. Threats to research security primarily arise from the failure of researchers applying for federal funding to disclose foreign affiliations, commitments, and sources of funding that may present a conflict of interest. Foreign talent recruitment programs have been found to incentivize or coerce participants to acquire “through illicit as well as licit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government.”<sup>45</sup> The academic research community has called for a coordinated and harmonized approach that balances the need to address security risks with the importance of scientific openness, international collaboration, and competing for global STEM talent.

### *Recent Legislative Actions*

Over the past 4 years, the Science, Space, and Technology Committee has worked to address many of these research security concerns and build a more effective and resilient R&D ecosystem. This Committee has consistently strived to balance security risks and the importance of scientific openness and international collaboration. Over the last four years, through the NDAA process and the CHIPS and Science Act, Congress has implemented:

- **Securing American Science and Technology Act.** The Fiscal Year 2020 NDAA included the Securing American Science and Technology Act, which established an interagency committee within the White House Office of Science and Technology Policy (OSTP) to coordinate research security across the Federal government.
  - The bill also established the National Science, Technology, and Security Roundtable at the National Academy of Sciences to facilitate collaboration between universities, federal agencies, law enforcement, and other stakeholders.
- **NSPM-33.** In response to the Securing American Science and Technology Act, the Trump Administration released National Security Presidential Memorandum-33 in January 2021 to direct a national response to safeguard the security and integrity of America’s R&D enterprise.
- **Disclosure Requirements.** The Fiscal Year 2021 NDAA included language that directed all Federal research agencies to require applicants to disclose foreign funding when receiving Federal research awards. This requirement ensures that there are consistent conflict of interest policies across agencies.

<sup>42</sup> [P.L. 116-260](#).

<sup>43</sup> [P.L. 117-167](#).

<sup>44</sup> JASON, The MITRE Corporation. *Fundamental Research Security*. December 2019. McLean, VA. Available at [https://www.nsf.gov/news/special\\_reports/jasonsecurity/JSR-19-21FundamentalResearchSecurity\\_12062019FINAL.pdf](https://www.nsf.gov/news/special_reports/jasonsecurity/JSR-19-21FundamentalResearchSecurity_12062019FINAL.pdf).

<sup>45</sup> National Science & Technology Council. Recommended Practices for Strengthening the Security and Integrity of America’s Science and Technology Research Enterprise. January 2021. Available at <https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/NSTC-Research-Security-Best-Practices-Jan2021.pdf>.

- **CHIPS and Science Act.**
  - **Prohibits Malign Foreign Talent Programs.** Title IV prohibits all federally funded research grantees from being a member of a malign foreign talent program or participating in similar activities.
  - **Prohibits Federal Employee's Participation in Foreign Talent Programs.** Title IV prohibits federal agency personnel from participating in foreign talent programs and requires researchers working on federally funded research projects to disclose any participation in foreign talent recruitment programs.
  - **Requires Annual Training on Foreign Threats.** Title IV requires all federally funded grantees to take annual training on research policies and foreign threats and directs OSTP to work with NSF and NIH to develop training for all grantees across the Federal research agencies.
  - **Requires Plans to Protect Sensitive Basic Research.** Title III directs NSF to develop a plan to identify research areas that may involve access to classified or controlled unclassified information and to exercise due diligence processes in granting access to such information.
  - **Bans Confucius Institutes.** Title III bans NSF funding from going to organizations hosting Confucius Institutes.
  - **Provides New Tools and Resources to Combat Foreign Theft.** Title III creates an Office of Research Security and Policy at NSF and gives the office and the Inspector General additional resources and new authorities to use analytical tools to detect and combat foreign influence, theft, and grant fraud. Title IV gives Federal research agencies the authority to require the submission of supporting documentation and the authority to act on findings that identify undue foreign influence or grant fraud.
  - **Requires Institutional Disclosure of Foreign Support.** Title III directs NSF to collect annual summaries of foreign financial support from universities and grants NSF the authority to request copies of contracts or documentation related to such disclosures.
  - **Gives Universities Tools to Protect Sensitive Research from Cyber Theft.** Title II directs NIST to assist universities in adopting the Cybersecurity Framework to help mitigate cybersecurity risks related to conducting research. In addition, title III directs the development of a national secure computing enclaves program to protect sensitive research information at American universities from cyber theft.

**Further Reading:**

- [The Perils of Complacency - America at a Tipping Point in Science & Engineering](#)
- [Protecting U.S. Technological Advantage](#)
- [Phase 2: Competing in the Next Economy – Adapting to a Changing World](#)
- [Defeating China and Saving Democracy](#)

Chairman LUCAS. Good morning, and welcome to the first Science Committee hearing of the 118th Congress. We're leading off with a discussion of how we can strategically improve U.S. scientific competitiveness and address the threats we face from the Chinese Communist Party (CCP). This is one of the most important challenges facing us at the moment, and I expect that global scientific leadership and competition with China will be a thread that runs through much of our upcoming work.

There are two reasons for that. First, America's economic strength, national security, and our quality of life are all fundamentally dependent on our ongoing scientific progress. In fact, more than 60 percent of America's economic growth in the last century is due to advances in science and technology (S&T). U.S. public investment in R&D (research and development) adds nearly \$200 billion in economic value. In basic research, in particular, increases long-term productivity across multiple industries.

The second reason for our focus on this topic, beyond our own economic benefits, is the threat that we face from the Chinese Communist Party. The CCP is determined to overtake us as the global leader in science and technology. They're outspending us, out-publishing us, out-educating us when it comes to STEM (science, technology, engineering, and mathematics) Ph.D. graduates. What's even more concerning is that they're working to steal the results of our research and innovations whether that's through cyberattacks, forced intellectual property (IP) acquisition, or malicious recruitment initiatives like the Thousand Talents Program.

I want to be very clear about the consequences of allowing the Chinese Communist Party to become the world leader in science and technology. It means fewer opportunities for American companies to compete in the global economy. It means increased risks to sensitive national security tools. And it means that critical technologies like artificial intelligence (AI), quantum information sciences, and cybersecurity tools will be shaped by and embedded with the CCP's values. If the CCC—if the CCP becomes the global leader in scientific discoveries and technology development, we should expect less privacy, less transparency, less access, and less fairness in how these systems operate, so we cannot afford to lose this competition.

When I first became Ranking Member of the Committee in 2019, finding a way to address this challenge became one of my first tasks. That led to the introduction of the *Securing American Leadership in Science and Technology Act* in 2020, comprehensive legislation to double down on our investment in basic research and develop a national strategy for scientific development. With *SALSTA* as a blueprint, our Committee began to develop bipartisan legislation to advance America's scientific and technological capacities.

There were a number of bumps along the road, but 2 years later, many of those ideas we first laid out in 2020 were passed in the Science as a part of the *CHIPS and Science Act*. When I talk about that bill, I want to point out that while funding for chips production is going to build factories today, it's the science portion of the legislation that will be the engine of America's economic development for decades to come.

Central to all of the investments and modernizations in the *CHIPS and Science Act* was the creation of a National Science and Technology Strategy. We directed the Office of Science and Technology Policy, OSTP, to develop a comprehensive strategy for America's science and technological development every 4 years. That strategy ensures a comprehensive whole-of-government approach to research and development, improving coordination between Federal agencies and a more strategic approach to prioritizing our resources. The national strategy will ensure that our time, energy, and funding for Federal research and development will be focused on the most important challenges facing our country. And given the increased funding we're giving to Federal R&D, this strategy is necessary to maximize the return on our investments and make good use of taxpayer dollars.

Today's hearing should serve a few purposes. First, to give us an overview of the current R&D enterprise; second, to examine the scope of the threat the CCP poses to our scientific leadership; and finally, to consider how best to develop a National Science and Technology Strategy. I expect the topics we discuss today to inform much of the work we'll do over the next year, from reauthorizing NASA (National Aeronautics and Space Administration) to expanding our domestic drone industry, to strengthening American clean energy technology. While there are significant challenges ahead of us, I'm very optimistic about our ability to face them and ensure that America continues to have a thriving scientific enterprise.

In the past 4 years, we have worked together in a deliberate, transparent, and bipartisan manner to pass meaningful legislation supporting American science and technology. Our goal is to continue that tradition in this Congress, and I'm looking forward to getting to work starting now.

[The prepared statement of Chairman Lucas follows:]

Good morning, and welcome to the first Science Committee hearing of the 118th Congress.

We're leading off with a discussion about how we can strategically improve U.S. scientific competitiveness and address the threat we face from the Chinese Communist Party.

This is one of the most important challenges facing us at the moment, and I expect that global scientific leadership and competition with China will be a thread that runs through much of our upcoming work.

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The second reason for our focus on this topic, beyond our own economic benefits, is the threat we face from the Chinese Communist Party.

The CCP is determined to overtake us as the global leader in science and technology. They're outspending us, out-publishing us, and out-educating us when it comes to STEM PhD graduates.

What's even more concerning is that they're working to steal the results of our research and innovations—whether that's through cyberattacks, forced intellectual property acquisition, or malicious recruitment initiatives like the Thousand Talents Program.

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that critical technologies like Artificial Intelligence, quantum information sciences, and cybersecurity tools will be shaped by and embedded with the CCP's values.

If the CCP becomes the global leader in scientific discoveries and technology development, we should expect less privacy, less transparency, less access, and less fairness in how these systems operate.

So we cannot afford to lose this competition.

Chairman LUCAS. And with that, I turn to my colleague for any opening comments that she would make.

Ms. BONAMICI. Thank you so much, Chairman Lucas, for holding today's hearing. Thank you to our distinguished panel of witnesses. Ranking Member Lofgren regrets that she is unable to be here today. She was very much looking forward to this hearing, and in particular, to discussing the critical importance of investing in fusion technology. And I ask unanimous consent to add her statement to the record.

Chairman LUCAS. Seeing no objection, so ordered.

[The prepared statement of Ms. Lofgren follows:]

Thank you, Chairman Lucas, for holding today's hearing. And I want to thank our distinguished panel of witnesses for joining us.

In 1942, facing an existential threat, the United States mobilized its scientific enterprise to split the atom. In a mere three years, the Manhattan Project created the world's first nuclear weapons in a race to end the second World War. The climate crisis facing the world today is no less profound. The threats of climate change—sea level rise and forced human migration, extreme weather, mass extinction—are existential. We must face these threats strategically—the same way we faced the threat of Naziism in World War II. The greatest challenge we face today is maintaining our energy security while confronting the threat of climate change. One of the key technologies in this effort is fusion energy.

So, I am particularly excited to hear from Dr. Kim Budil today. Last fall, Dr. Budil and her colleagues at Lawrence Livermore National Laboratory (LLNL) announced a true breakthrough in fusion—the achievement of ignition at the National Ignition Facility (NIF). I think this is one of the most important scientific achievements of our time. However, there are still many technical challenges ahead to achieve commercial scale fusion energy. It is essential we maintain the funding commitment to see this vital technology's promise be fully realized. I think a Manhattan Project level of commitment is needed now to ensure that the incredible promise of fusion energy is achieved.

But it takes more than funding to realize the success of game-changing technologies like fusion energy. We also need a strategic vision. The United States had this vision during World War II when we split the atom. We had this vision when we won the Space Race and put a man on the moon. And we need this strategic vision now as we face the climate crisis and threats to our economic competitiveness and national security.

A critical piece of the *Chips and Science Act* we passed last year is the requirement for the White House to develop and regularly update a national science and technology strategy, and conduct a quadrennial science and technology review. This strategy, informed by the quadrennial review, will help provide us with a unifying vision of how to maintain American leadership in science and technology. While our science agencies excel at carrying out their individual missions, a unifying vision will help ensure the U.S. science and technology enterprise is greater than the sum of its parts.

I look forward to hearing more from our witnesses today and to discussing how this science and technology strategy can best serve our nation. I also want to consider how this strategy will incorporate and address critical technologies like fusion energy. You know, it's not enough to just have the incredible scientific achievements like we had with ignition. We need to accompany those scientific achievements with technology development so we can fully realize the potential of these scientific breakthroughs.

We also need to be thinking down the road to associated deployment issues like licensing and supply chain. We need whole-of-government and in fact whole-of-nation strategic planning, in partnership with the private sector, for these profoundly important technologies so that we don't repeat the mistakes we've made in the past in areas like semiconductors and that we are at risk of making in emerging technologies. Our commitment must be for the long term, so that we can lead in the

responsible development and manufacturing of the world's advanced technologies here in the United States.

As we race forward to develop solutions to the climate crisis and other challenges that face our nation, we need to ensure that the United States can reap the full rewards of our scientific achievements.

Thank you, and I yield back my time.

Ms. BONAMICI. Thank you. For more than 70 years, the United States has been the unquestioned global leader in science, technology, and innovation, reaping the benefits of—to our economic and national security and overall quality of life. This leadership was built on the vision and political will of our leaders in the aftermath of World War II. They enacted the *National Defense Education Act*, created the National Science Foundation (NSF) and NASA, and made other unprecedented investments in our Nation's talent and technology.

Over time, however, we became complacent, and our commitment to nondefense R&D waned. At the same time, much of our manufacturing capacity went offshore, making our supply chains vulnerable and risking our economic and national security. Our insufficient commitment to research and domestic manufacturing left an opening for other countries, and they seized it. China and Europe increased their investments in critical technologies and emulated our innovation systems in building theirs.

Last year, the Committee on Science, Space, and Technology took a significant step to reinvigorate the U.S. Science and Technology enterprise with the bipartisan *CHIPS and Science Act*. And thank you, Mr. Lucas, for emphasizing the “and science” part of that bill. This law is already starting to bring good-paying manufacturing jobs back to the United States, and it's accelerating the development of future industries across our country. In fact, today, the Commerce Department is announcing the first application for *CHIPS* funding, specifically for manufacturing facilities, so we can start to invest in domestic companies and their workers and incentivize innovation and production in America.

Because of the *CHIPS Act*, Intel, which has its research facilities in the district I'm honored to represent in Oregon, has committed to investing \$20 billion in two new leading-edge semiconductor fabrication facilities. A key provision of the *CHIPS and Science Act* requires the White House to conduct a quadrennial science and technology review and develop a National Science and Technology Strategy. This provides us with a tremendous opportunity, an opportunity to have a coherent all-of-government approach to our investments in science and technology that will grow U.S. leadership, bolster our competitiveness, and safeguard national security.

As several of the witnesses noted in their testimony, to achieve these goals, we will—we must think broadly about who is at the table to inform the strategy. We must solicit and welcome the input of the private sector, communities that have historically been left out of setting research agendas, and everyone in between. Inclusion in setting the agenda is essential to the responsible development of technology that benefits all Americans and leaves no one and no American behind.

As the witness testimony makes clear, innovation is key. We need creative critical thinkers around the table, people who can come up with new ways to view challenges and inventive ways to

solve problems. As a Member of the Education and Workforce Committee and co-Chair of the STEAM (science, technology, engineering, arts, and mathematics) Caucus, I advocate for the integration of arts and design into traditional STEM fields, which inspires creativity and increases the competitiveness and diversity of the workforce.

The National Strategy is also an opportunity for us to reimagine how we can integrate the goal of a circular economy, a new model of manufacturing and consumption that focuses on long-term sustainable growth across our research agenda and lead in the responsible development of technology. Through our S&T strategy, we can leverage scientific investments to tackle our greatest challenges. With the climate crisis threatening the Nation and the globe, we can invest in sustainable solutions to mitigate and adapt. The circular economy does not just apply to the energy sector and transportation. It applies to chemicals, materials, food production, manufacturing, and more. I urge OSTP to keep up all of the issues discussed in this—to keep all of the issues discussed in this hearing is—in mind as they begin to develop a National Science and Technology Strategy. I look forward to hearing more from our witnesses today and to discussing how this important strategy can best serve our Nation.

Thank you, Mr. Chairman, and I yield back my time.

[The prepared statement of Ms. Bonamici follows:]

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ting research agendas, and everyone in between. Inclusion in setting the agenda is essential to the responsible development of technology that benefits all Americans and leaves no issue, and no American, behind.

And as the witness testimony makes clear, innovation is key. We need creative, critical thinkers around the table; people who can come up with new ways to view challenges and inventive ways to solve problems. As a member of the Education and Workforce Committee and Co-Chair of the STEAM Caucus, I advocate for the integration of arts and design into the traditional STEM fields, which inspires creativity and increases the competitiveness and diversity of the workforce.

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I urge OSTP to keep all of the issues discussed in this hearing in mind as they begin to develop a national science and technology strategy.

I look forward to hearing more from our witnesses today and to discussing how this important strategy can best serve our nation.

Thank you, and I yield back my time.

Chairman LUCAS. The gentlelady yields back her time.

I would like to thank our witnesses for joining us this morning for this important discussion. Dr. Kelvin Droegemeier is the former Director of the White House Office of Science and Technology Policy and currently the Regents' Professor of Meteorology and Weathernews Chair Emeritus, and the Roger and Sherry Teigen Presidential Professor at the University of Oklahoma (OU). He co-founded and directed one of the National Science Foundation's first Science and Technology Centers and served as Vice Chairman of the National Science Board. Thank you for being here.

Ms. Deborah Wince-Smith is the President and CEO of the Council on Competitiveness, a coalition of leaders from industry, academia, and our national laboratory directors committed to driving U.S. competitiveness. She has more than 20 years of experience as a government official, which includes serving as the first Senate-confirmed Assistant Secretary for the Technology Policy at the Department of Commerce.

And Dr. Kim Budil is the Director of the Lawrence Livermore National Laboratory, which is responsible for ensuring the safety, security, and reliability of the nuclear stockpile. The doctor has three decades of experience at LLNL, where she has used her background in applied science and engineering to advance science and improve our national security. Thank you, too, for joining us.

And lastly, we have Dr. Klon—Mr. Klon Kitchen from the American Enterprise Institute. Mr. Kitchen analyzes the interaction of national security and defense technologies and innovation. He focuses on technologies of the future like cybersecurity, national intelligence, robotics, and quantum sciences.

Thank you all as witnesses for being here today and sharing your expertise.

And with that, Dr. Droegemeier, we'll turn to you first for your testimony.

**TESTIMONY OF DR. KELVIN DROEGEMEIER,  
REGENTS' PROFESSOR OF METEOROLOGY  
AND WEATHERNEWS, CHAIR EMERITUS  
ROGER AND SHERRY TEIGEN  
PRESIDENTIAL PROFESSOR, UNIVERSITY OF OKLAHOMA  
AND FORMER DIRECTOR, WHITE HOUSE OFFICE  
OF SCIENCE AND TECHNOLOGY POLICY**

Dr. DROEGEMEIER. Thank you so much, Mr. Chairman. Good morning, and thank you so much for the privilege of testifying. We send our best wishes to Ranking Member Lofgren and Congresswoman Bonamici. It's great to see you. Thank you for your long service here on this important Committee.

Thank you all for the support of science and technology that you render to our Nation. I just want to say the comments that I'm going to make this morning really reflect my own comments and not those of my home institution.

As the Chairman said, our extraordinary leadership, our global leadership in science and technology is being challenged as never before. And numerous studies bear this out, and he cited many statistics. You know, we became a global leader for many reasons, but two of them stand out, and I really want to highlight them for you.

First and foremost, we became a global leader because of our values and our freedoms, the freedom to discover and create, the freedom to debate, to challenge one another, the freedom to speak freely, freedom to share a free market system where we can take our ideas and develop new private companies and developed capabilities for the benefit of humanity, and most importantly, the freedom to pursue our own pathways and our own dreams. Now, interestingly, these very freedoms and values are congruent with the very values by which we actually conduct research, namely honesty, integrity, reciprocity, accountability, impartiality, objectivity, the ability to really rigorously debate and then do so with great civility and also merit-based competition.

In a world where clearly values and freedoms like I just mentioned are not universally treasured and reinforced, and where authoritarian regimes seek to undermine longstanding norms and international order, we, as the United States, must maintain our global leadership position in science and technology, not only by virtue of our contributions, but also by leading with our values.

We also became a global leader in U.S. science and technology, which includes government, academia, and for-profit and private companies, because of this wonderful ecosystem. It's very important that the National S&T Strategy be structured as what I call a whole-of-nation plan, involving, as Congresswoman Bonamici said, all sectors of our S&T enterprise in a very integrated manner so that everyone that looks at that plan, whatever sector they're in, they see themselves in that plan, all the way from the beginning, all the way through execution.

Our National S&T Strategy should be like no other. It should be absolutely bold and transformative and disruptively creative in our work and guiding us into the future. It should unite us and inspire us by the bold ideas it puts forward. It should streamline administrative procedures and structures that tend to hamper our work

and tie our own hands, empowering all of our scholars and researchers to unleash their full creative capabilities.

Most importantly, in this strategy, we need to leave politics behind, and I think this Committee is a great example of that. We have to begin with a set of guiding principles in which all S&T sectors and political parties can agree. And I believe OSTP's current leadership is exceptionally qualified to lead in this effort.

Now, a 4-year S&T strategy is fantastic, and I absolutely support that idea, but I think it needs to be constructed within a longer-term framework, what I call kind of a 25-year horizon or arc that does not identify specific technologies or research areas of investment, but rather it describes in very broad strokes a U.S. vision for its future in terms of research and education and technology, domestic and international partnerships, and also national and international norms of behavior. By taking such a long-haul view, which is exactly what the Chinese Government does, they don't think the next election cycle, the next 4 years. They think the next 20 years. By doing that, I think we will for the first time perhaps since World War II, as Congresswoman Bonamici said, we will have the chance to have a multidecadal national context within which will reside this important 4-year strategic plan.

Now, obviously, we cannot underestimate the importance of human capital to the future of our S&T enterprise. I personally believe that we need a STEM—a national STEM workforce and talent initiative similar in many respects to the GI Bill, which would leverage and, in many cases, supplant a lot of the individual workforce initiatives that are out there. What I'm saying is we have a lot of flowers growing, we have thousands of flowers growing, but we need to plant some beautiful, lush gardens that we tend and that we really think of in a national context.

This S&T strategy is also beautifully positioned—and I thank Congress for that—to provide a very bold vision for moving forward to a skills-based education and workforce environment where an assemblage of demonstrated skills and capabilities not just degrees is the coin of the realm.

We also need to safeguard our science and technology, and I know we'll talk about today. We face new and ever-growing challenges and threats of foreign interference in our S&T enterprise. Now, numerous activities are underway to address these threats, including many things at academic institutions. Safeguarding our research is actually another wonderful opportunity for us in the U.S. to lead with our values, to welcome foreign collaborators who may not be familiar with the kinds of ethical conduct and research based on where they actually developed their skills and were educated. But we have that here in the United States, and we can help ensure that their behavior and the behavior of everyone in our enterprise, whether it's from Norman, Oklahoma, where I'm from, or Beijing, China, everyone plays by the rules, everyone adheres to the rules, and we uphold the highest professional standards of ethical conduct.

And finally, and perhaps very importantly, being a global leader in science and technology means we don't play to not lose. We cannot depend upon a growing international S&T enterprise, which is a good thing and is lifting all boats. We can't rely on that to lift

our boat, as well as everyone else's. With this National S&T Strategy that you, Congress, have challenged us to develop and I think we are ready to do this, it could have a very, very strong and powerfully unique game plan for the future—that is, we in America can—leading with our values, working with the international community, and investing wisely and boldly to ensure that we remain, our ship remains the highest ship on the seas.

Mr. Chairman, thank you, and I look forward to questions.

[The prepared statement of Dr. Droegemeier follows:]

**Written Testimony of Dr. Kelvin K. Droegemeier  
Regents' Professor of Meteorology and Weathernews Chair Emeritus  
Roger and Sherry Teigen Presidential Professor  
University of Oklahoma  
and  
Former Director  
White House Office of Science and Technology Policy (OSTP)**

**Submitted to the Committee on Science, Space and Technology  
United States House of Representatives  
for the hearing titled  
*United States, China and the Fight for Global Leadership: Building a U.S. Science and  
Technology Strategy*  
Tuesday, February 28, 2023, 10:00 am EST  
Rayburn House Office Building, Room 2318**

I thank Chairman Lucas, Ranking Member Lofgren, and Members of the Committee for the privilege of testifying on the important topic of U.S. competitiveness in science and technology. I also am grateful to Committee staff for the hard work they do behind the scenes each and every day, and in organizing this hearing.

My name is Kelvin K. Droegemeier, and I am Regents' Professor of Meteorology, Weathernews Chair Emeritus, and Roger and Sherry Teigen Presidential Professor at the University of Oklahoma. I also am former Vice President for Research at the University of Oklahoma, former Oklahoma Cabinet Secretary of Science and Technology, and former member of the National Science Board (2004-2016), serving the last four years as Vice Chairman. From 2019 until 2021, I served as Director of The White House Office of Science and Technology Policy (OSTP) and Science Advisor to the President. For two and a half months during my time at OSTP, I also served as Acting Director of the National Science Foundation. I am testifying today solely in my roles as an academic teacher, researcher, administrator, and contributor to national science and technology policy. My views and recommendations do not reflect those of the University of Oklahoma or its Board of Regents.

This Committee has long been a bi-partisan champion of science and technology, and over many years has enacted important legislation to foster national prosperity, economic security, quality education, and international competitiveness through research, especially that which is born out of human curiosity but ultimately finds its way into practical uses which transform society. Nowhere has this been more evident than during the COVID-19 pandemic, where fundamental research in biology, mathematical modeling, human behavior, biochemistry, advanced telecommunication, artificial intelligence, supply chain management, manufacturing and, of course, human health, allowed us to lead the world in understanding and taking measures to address a global crisis.

The pandemic made ever clearer the importance to humanity of science and technology research and development, and thus I deeply appreciate this Committee's work on the CHIPS Act of 2022, which contains numerous provisions that will help ensure U.S. leadership in science and technology. Among the most important is a bottom-up quadrennial assessment of our entire

science and technology research and development enterprise, along with the creation of a National Science and Technology Strategy. I worked toward exactly these same goals while at OSTP, so I am especially encouraged to see this Committee hold a hearing on U.S. competitiveness through the lens of these important activities. I also appreciate the opportunity to provide input, and I stand ready to help in whatever ways you believe to be most beneficial.

### 1. The Big Picture: U.S. Global Leadership in Science and Technology

Countless reports have been written about the evolution of U.S. global leadership in science and technology (S&T) following World War II, underpinned in many respects by Vannevar Bush's 1945 seminal treatise, *Science: The Endless Frontier*.<sup>1</sup> Consequently, I need not recount here the many extraordinary S&T outcomes pioneered by the U.S. and its international collaborators, which have contributed to economic prosperity, national security, improved health and quality of life, and a brighter outlook for future generations. However, I do wish to describe what I consider to be the two most important factors in achieving this success, and which should figure prominently in the National S&T Strategy (hereafter NSTS) required by the CHIPS Act.

**The first concerns our values and freedoms** – the freedom to discover and create; the freedom to debate, challenge, and speak freely; the freedom to share; a free market system to transition research outcomes into practice for the benefit of humanity; and the freedom to pursue our own pathways and dreams. Importantly, and not surprisingly, these values are congruent with the very values by which research itself is conducted, namely, honesty, integrity, transparency, accountability, impartiality, objectivity, reciprocity, rigorous civil debate, respect, and merit-based competition.

The U.S. has always been a beacon of values and freedom to the world, and that beacon shines brightly from our research enterprise. **In a world where values and freedoms are not universally treasured and reinforced, and where authoritarian regimes seek to undermine longstanding norms and international order, the U.S. must maintain its global leadership position in S&T not only by virtue of its contributions, but also by leading with its values. Consequently, the NSTS should be built upon a set of principles and values that reflect the essence of our Nation's foundation and the conduct of research itself.**

**The second factor concerns the multi-sector U.S. S&T enterprise**, comprising academic institutions, which perform research and educate the next generation workforce; state and Federal government organizations, which both fund as well as perform research; for-profit companies, which innovate research outcomes to create products and services beneficial to society; and non-profit organizations, which fund research, help identify future priorities, organize and support professional communities, and contribute to policymaking. Our well over \$600 billion yearly expenditures in S&T research and development (R&D) occur within this powerful ecosystem, which boasts trillion-dollar companies, support structures which have funded numerous Nobel Laureates and countless other scholars, five or more of the world's top 10 research universities (depending upon the source of the rankings), and 17 U.S. Department of Energy (DoE) National Laboratories which are unique in the world. **Therefore, it is vitally important that the NSTS be structured as a whole-of-Nation plan, involving all sectors of the U.S. S&T R&D ecosystem in an integrated manner – from planning through execution. As noted below, every sector should “see itself” in the plan and be able to use the plan to help chart its course for the future.**

## 2. The U.S.-China S&T Relationship: Collaboration, Competition, and Concerns

S&T R&D inherently are both domestic as well as multi-national activities, ranging from individual faculty collaborations on fundamental/curiosity-based research to massive, long-term corporate projects or multi-national facilities such as telescopes and particle accelerators. The benefits of such collaborations, and the contributions made to them by foreign nationals studying or working in the U.S. – including individuals from China – are well established<sup>2 3 4</sup> and have yielded important benefits for society. Examples include the rapid identification of the COVID-19 virus and development of vaccines and other therapies to combat it; the first image of a black hole shadow; and foundational theories of turbulence in fluids, to name but a few. Collaboration quite often yields the best outcomes by bringing to the table a diversity of ideas and perspectives, thereby enriching the research and promoting learning and a broadening of views.

**Collaboration between the U.S. and China in S&T** can be evaluated in a variety of ways, ranging from funded projects or formal publications involving researchers from both nations to educational exchange programs. As an example of the former, in 2020, 22% of all science and engineering (S&E) articles produced in China had international co-authors<sup>a</sup>, while in the U.S., the figure was 40%.<sup>5</sup> Slightly over 26% of U.S. international articles had U.S. and Chinese co-authors, up from 14% in 2010.<sup>5</sup> Indeed, the number of publications having both U.S. and Chinese co-authors grew steadily from approximately 10,000 in 2007 to approximately 62,000 in 2019.<sup>6</sup> About one-third of the papers in 2019 had authors with dual U.S.-China affiliations, though that number fell sharply through 2021.<sup>6</sup>

As in most aspects of society, including sports, private business, and even families, competition is valuable if pursued in an appropriate manner. S&T research is no exception, and **China clearly is seeking to establish global dominance in S&T and thus is an important competitor for the U.S.** Xi Jinping, President of the People's Republic of China (PRC), stated the following during an address on May 28, 2021 to the Chinese Academies of Sciences and Engineering, and the China Association for S&T<sup>7</sup>:

*“Science and technology self-reliance and self-strengthening should always be considered a strategic support for national development. Scientific and technological development must target the global science and technology frontiers, serve the main economic battlefields, strive to fulfill the significant needs of the country and benefit people's lives and health. Scientists and engineers must closely follow current trends, take the initiative, confront problems head-on, and overcome difficulties.”*

China has made significant investments in S&T and has begun to reap significant benefits from them. Its strategic innovation triangle<sup>7</sup> involves a 15-year medium-long term S&T Plan, Education Reform Plan, and Talent Plan. China's internal expenditures on R&D grew in 2020 to

<sup>a</sup> From the source document, “articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a whole count basis (i.e., each collaborating country or economy is credited with one count). Articles without international co-authorship are counts of articles with one or more institutional addresses all within a single region, country, or economy, which include single-author articles and articles coauthored under the same institutional address. International articles are articles with institutional addresses from more than one country or economy.

over 2.4% of gross domestic product (GDP) and could reach 2.8% if current trends continue.<sup>7</sup> By comparison, the U.S. in 2020 expended 3.45% of GDP.<sup>8</sup> Gross domestic R&D expenditures by China in 2019 were \$526 billion compared with \$658 billion for the U.S.<sup>9</sup> In terms of purchasing power parity (PPP)<sup>b</sup> dollars, China has been accelerating its investments rapidly since the early 2000s and likely has overtaken the U.S. by now in both real dollars and percentage of global share.<sup>10</sup> China's R&D spending focuses mostly on experimental and applied work conducted at enterprises other than universities.<sup>7</sup> Since approximately 2010, the source of Chinese government funding for R&D has shifted from the central to local governments.<sup>7</sup>

One important measure of originality in innovation, and the translation of research outcomes into practical benefits for society, is the patent. A recent article by the Center for Strategic and International Studies<sup>11</sup> notes that, based upon raw aggregated data, China began to emerge in 2010 as the world's leader in patent applications and grants, exhibiting significant yearly increases thereafter. Conversely, U.S. trends have been much more modest, resulting in China having more than twice the number of patent applications in 2020.<sup>11</sup> Of course, a more important measure is the number of patents granted, and by that measure, China has a roughly 50% lead compared to the U.S.<sup>11</sup> One must be careful in interpreting this figure, however, because it is believed<sup>12</sup> that much, if not most of China's patents do not have value in the marketplace, and that factors other than the desire to protect intellectual property for innovating products and services are at play.

Turning to education, in 2016, China produced more than twice the number of first (baccalaureate) university degrees in S&E compared to the U.S. (which produces the second most).<sup>13</sup> Some 15 years earlier, China was in third place globally. As of 2018, the U.S. awarded slightly more S&E doctoral degrees than China (41,071 compared to 39,768).<sup>14</sup> In 2020, the U.S. awarded 42,622 S&E doctoral degrees,<sup>15</sup> with 13.4% awarded to temporary visa holders from China.<sup>16</sup> Also in 2020, nearly three-quarters of doctoral recipients on temporary visas in the U.S. said they intended to remain here, which is an increase of some four percentage points since 2010.<sup>17</sup>

It has been said that research and innovation anywhere are good for research and innovation everywhere, and that a rising tide lifts all boats. Both are true. However, **the U.S. cannot rely on the global rising tide of S&T research and innovation to lift its boat. It must develop a bold, transformative S&T Strategy that allows it to sail higher, move more quickly, unleash the creative talents of every individual, collaborate intentionally, and lead globally with its values (see below).** The CHIPS Act provides an opportunity to do just that.

### 3. Thoughts on Developing the National S&T Strategy and Quadrennial S&T Review

Congress has provided the Nation with an important and unprecedented opportunity to take full stock of its current capabilities in S&T across all relevant sectors, and to develop a forward-

<sup>b</sup> According to the Organization of Economic Cooperation and Development (OECD; [oecd.org/sdd/purchasingpowerparities-frequentlyaskedquestionsfaqs.htm#FAQ1](https://oecd.org/sdd/purchasingpowerparities-frequentlyaskedquestionsfaqs.htm#FAQ1)), "PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including GDP."

looking strategy congruent with and supportive of other Federal plans and strategies for which S&T are foundational to domestic success and global leadership. I offer in this section views and recommendations regarding the NSTS and Quadrennial S&T Review (hereafter QSTR).

**Point #1. Scope and Structure of the NSTS.** As noted previously, it is vitally important that the NSTS be structured as a whole-of-Nation plan, involving all sectors of the U.S. S&T R&D ecosystem in an integrated manner – from the very inception of planning through execution. Every sector should “see itself” in the plan, and organizations within each sector should be able to use the plan to help chart their course for the future in a manner that supports national goals but is not dictated by them. **Additionally, and very importantly, participating stakeholders should be drawn from sources in addition to the most prestigious and highly ranked organizations.** In the case of academic institutions, this includes but is not limited to individuals from EPSCoR (see below) jurisdictions, Minority Serving Institutions (MSIs), Historically Black Colleges and Universities (HBCUs), emerging research institutions (ERIs, defined as institutions having less than \$50 million per year in Federal research expenditures), rural institutions, and two- and four-year institutions.

Although developing the QSTR and NSTS will be monumental tasks, even more difficult and important will be ensuring their effective use. We are all too aware of massive strategic plans which mostly sit on the shelf and then are set aside after elections. This must not be the case here, which leads to the next point.

Because the NSTS and QSTR are arguably broader than any assessments or plans ever developed, it will be impossible to construct them in a traditional manner, e.g., by mining numerous reports from Federal agencies, private companies, academia, and non-profit organizations, and conducting listening sessions and focus groups. Consequently, **the power of artificial intelligence (AI) should be brought to bear to assemble and synthesize information across all sectors and key organizations, identify gaps and needs, draw comparisons with the plans of other nations, and empower the developers of NSTS and QSTR to propose bold new ideas and pathways.** AI was shown to be profoundly important in the COVID-19 pandemic, especially in synthesizing information from the thousands of publications which were emerging at extraordinary speed (see below). AI can play an even greater role with the NSTS and QSTR.

**Point #2. A Plan Like No Other.** The NSTS should put forth a strategy that is **highly transformative and disruptively creative**, taking a bottom-to-top approach that enables a seamless ecosystem among all sectors of the U.S. S&T R&D enterprise. It should be like no other plan, domestic or international, and do what research itself does: *Inspire us with bold ideas, unite us in our work, and guide us into the future.*<sup>18</sup>

Although we tend to speak about innovation in the context of S&T, it is important to recognize that **policy and administrative frameworks can be equally innovative.** Our ability to work across sectors is significantly challenged,<sup>19</sup> and researchers are overwhelmed by rules and regulations that tie our hands rather than loosen our creative capabilities. The fact that faculty in our universities spend, on average, between 42% and 44% of their time on administrative activities, unrelated to research,<sup>20</sup> is completely unacceptable – especially given that these percentages have not changed meaningfully in

over two decades despite the addition of research administrative and regulatory compliance personnel at many universities. And indeed, those percentages likely will increase with additional administrative tasks related to safeguarding research, as noted below. These and other challenges have been known for many years, yet no significant relief has been forthcoming despite well-intentioned attempts. The NSTS and QSTR have an opportunity to drive the needed change.

Because many of the needed changes are difficult to achieve *en masse*, **the NSTS could propose a set of experiments (e.g., in academic-corporate partnerships; Federal research assistance awards to academic researchers) in which specific stifling regulations are temporarily suspended or streamlined (e.g., via Executive Order) as a proof-of-concept, with the outcomes used to implement broader change.** The COVID-19 pandemic provided an unfortunate experimental framework where, owing to urgency and uncertainty, capabilities were developed which otherwise would not have occurred (e.g., the CORD-19<sup>21</sup> data base of publications and artificial intelligence applications, the nascent National Strategic Computing Reserve,<sup>22</sup> and of course, Operation Warp Speed<sup>23</sup>). Lessons learned from these and other activities should inform bold recommendations within the NSTS.

**Point #3. Leave Politics Behind.** The NSTS and QSTR should be **entirely apolitical and bi-partisan**, avoiding some of the political overtones in previous plans and assessments. The best way to accomplish this goal is to begin with a set of **guiding principles** to which all S&T sectors and political parties can agree, and use them as a North Star when challenging issues tend to create division on specific topics. I am pleased Congress chose The White House Office of Science and Technology Policy (OSTP), rather than specific departments or agencies, as the focal point for developing the NSTS and QSTR. Its current leadership is exceptionally qualified to lead these initiatives and has demonstrated its ability to view S&T through an objective lens.

**Point #4. Broaden the Engagement of Institutions.** Considerable focus has been placed recently, including in the CHIPS Act and with good reason, on providing additional funding for research to MSIs, HBCUs, and ERIs. However, often overlooked is the fact that such institutions lack the administrative capabilities to assist their faculty and other researchers in identifying and pursuing funding, managing awards once received (including the significant amount of reporting and compliance involved), commercializing intellectual property, developing multi-sector partnerships, and addressing issues of foreign government interference (see below). Consequently, simply providing more funding for research, without addressing the administrative challenges, can set such institutions up for failure, or at least significant problems.

Steps are being taken to address this capability gap to enable many more academic institutions to participate in the U.S. research enterprise. One unique example is the NSF GRANTED (Growing Research Access for Nationally Transformative Equity and Diversity) program<sup>24</sup>, which “focuses on addressing systemic barriers within the nation’s research enterprise by improving research support and service capacity at emerging research institutions.” **It is important that the NSTS recognize the value of engaging every type of institution in the U.S. academic research enterprise, building upon the GRANTED concept and creating not only research, but also administrative**

partnerships across the spectrum of our Nation's institutions – large and small, public and private, long established and just getting started.

**Point #5. Take the Long View.** Congress has detailed in the CHIPS Act several key components of the NSTS, including that it spans four years. I support that idea. However, **the NSTS should be constructed within the context of a 25-year “horizon or arc,” which does not identify specific technologies or research areas of investment – for doing so is impractical – but rather describes, in broad strokes, a U.S. vision for its future in terms of research, education, technology, domestic and international partnerships, and national and international norms of behavior.** By taking such a long view – which in fact is precisely how China operates – the U.S. could have, perhaps for the first time since World War II, a multi-decadal national context for its S&T future, within which resides a specific plan for the next four years.

This approach has the benefit of preserving the ability of the research and technology communities to take the lead in determining which activities should receive the greatest attention and resources. Although it may be tempting to create prioritized lists of specific S&T topics to be pursued (e.g., quantum computing, biotechnology, artificial intelligence, climate change), I believe we do not have such luxury. Rather, these and numerous other areas represent high priorities for the future in today's exciting but dangerous world. Consequently, the NSTS should identify **foundational elements of these and other societal imperatives** (e.g., data, communication, computation, experimentation) and ensure *they* are addressed – thus allowing numerous activities which build upon them to emerge and thrive.

**Point #6. It Boils Down to People.** One cannot overstate the importance of human capital to the future of U.S. science and technology research and education. Countless reports have been written about the trajectory of demographics in the U.S., the need for both a skilled STEM (science, technology, engineering, mathematics, medicine) workforce and a skilled technical workforce, the importance of international students and workers, and the need to engage those who are traditionally underrepresented, underserved, and under-resourced. Hundreds of billions of dollars have been invested in a wide array of initiatives, national strategies have been written, and important progress is being made.

**However, the NSTS and QSTR provide the U.S. with an opportunity, as never before, to coordinate workforce development on a national scale with broad national goals that involve all sectors of the S&T enterprise.** I personally believe **the U.S. needs a national STEM workforce/talent initiative, similar in many respects to the GI Bill**, which could both leverage and in some cases supplant current individual workforce initiatives and achieve what they alone have been unable to do. Namely, identify and educate what the National Science Board calls the Mission Millions.<sup>25</sup> **Such an initiative, which should include a participant service component to the Nation as well as a commensurate program to substantially build the teaching workforce,** would in my view be much more efficient, and lead to greater progress much more quickly, than the current array of (in many cases) disconnected programs. It also could address important issues raised in a new report by the National Academies of Science, Engineering and Medicine on diversity, equity and inclusion in STEM organizations.<sup>26</sup>

Additionally, the future of education, industry requirements for workers, and how individuals view themselves is not about degrees and years of service, but rather about skills, competencies, and credentials. **The NSTS is ideally positioned to provide a bold vision for moving toward a skills-based education and workforce environment, where an assemblage of demonstrated skills and capabilities is recognized as the coin of the realm.** The winds of change already are blowing in this direction, and the multi-sector approach for NSTS is ideally suited toward engaging this topic in a coordinated national manner.

**Point #7. The Essential Role of Partnerships.** As noted previously, the U.S. multi-sector S&T enterprise is extraordinary in its historical evolution, capabilities, and achievements. Yet, partnerships among the sectors, and even across Federal agencies, remain onerous and overly complicated owing to regulations, differing perspectives, and historical inertia. Progress happens, but the cost in terms of time and talent is far greater than it should be. Why are partnerships important and why do we need them? Because partnerships bring together people, ideas, funding, facilities, and other resources to achieve certain important goals which otherwise would be unattainable.

One relatively simple solution – which is applied occasionally – is to **have the heads of Federal R&D agencies develop relationships with heads of private non-profit and for-profit companies to “set the table” for the strategic manner in which they might partner.** All three types of organizations have different philosophies, administrative and governance structures, capabilities, and rules and laws under which they operate. This is in fact an extraordinary strength that can be leveraged in partnerships, for when two or more join together, amazing things can happen. Yet, all too often, we leave it to individual researchers or centers to build S&T relationships with companies or non-profit foundations. In many cases, the researchers are not skilled in building such relationships, especially for institutions which traditionally have not engaged in such activities. Although such interactions need to occur, we need to add strategic, institutional-leader-to-institutional-leader coordination that establishes a framework for partnering, which then can be executed by others within the organizations. This will greatly broaden the number and type of institutions participating in partnerships and lead to collateral benefits such as local and regional economic development, especially in disadvantaged regions.

**Indeed, regional innovation is key,** and important strides are being made in this regard, e.g., by the NSF Regional Innovation Engines and DoE Innovation Hubs. In fact, a recent report<sup>27</sup> on the future of the NSF EPSCoR (Established Program to Stimulate Competitive Research) program emphasizes jurisdictional (i.e., state-level) transformation via the collective engagement of universities, state government, for-profit companies, business organizations such as Chambers of Commerce and the Business Roundtable, and non-profit organizations.

**Point #8. Safeguard Science and Technology.** In developing the NSTS, we must recognize, as Congress did in writing the CHIPS Act (and NDAA as well), that **the U.S. faces new and ever-changing threats of foreign interference to its S&T enterprise.** Examples include failure to protect confidential information in grant proposals and subverting the peer review process, failure to disclose required information including

conflicts of interest and commitment, misappropriation of research results and credit, and outright theft of intellectual property.<sup>28 29 30 31 32 33 34 35 36</sup> In partial response, OSTP established in 2019 the Joint Committee on the Research Environment (JCORE)<sup>37</sup> within the National Science and Technology Council (NSTC). A particularly important JCORE sub-committee addresses issues of research security to ensure an **appropriate balance exists between the openness needed for U.S. research to thrive, including via principled international collaboration, and the protection of research ideas, methodologies, processes, data, and technologies prior to their formal publication or intellectual property protection.**

Numerous activities are underway to address research security challenges, starting with National Security Presidential Memorandum #33 (NSPM-33), issued in January, 2021.<sup>38</sup> An NSTC report was issued that same month on recommended practices in research security for research organizations (universities, private companies, independent research institutes),<sup>39</sup> and in January, 2022, OSTP issued guidance to Federal R&D agencies on implementing NSPM-33.<sup>40</sup> Numerous others activities are underway, as specified in the CHIPS Act and NDAA, including in the former the creation by NSF of a Research Security and Integrity Information Sharing Analysis Organization (RSI-ISAIO). Additionally, workshops and studies are underway by government organizations, disciplinary societies, professional associations, and the National Academies of Science, Engineering and Medicine (NASEM).

Universities are responding as well, and the Massachusetts Institute of Technology (MIT) created an especially thoughtful approach to engaging with China<sup>41</sup> that is being considered by other institutions. Yet, the cost of such actions is significant, not only monetarily to taxpayers viz Federal funding agencies and research institutions, but also to researchers themselves in the form of increased administrative overhead at the expense of conducting research.<sup>42</sup> **We must be careful to empower our researchers, not constrain them unnecessarily.**

At the end of the day, research security boils down to behavior – namely, playing by the rules. This means understanding the rules, seeing them modeled, knowing how to comply with them, and being aware of the consequences of non-compliance. **Here again is an opportunity for the U.S. to lead with its values – to welcome foreign collaborators who may be less familiar with ethical conduct in research based upon the environments in which they were educated and trained, and to ensure their behavior, as well as the behavior of everyone in the U.S. research enterprise, reflects the highest professional standards and adherence to laws and policies.**

**Point #9. Bring Benefits to the Public.** The general public is the most important stakeholder in the U.S. S&T enterprise. This point was underscored by the National Science Board in its Vision 2030 report<sup>25</sup>, for which one pillar of its roadmap is Delivering Benefits from Research. **The NSTS likewise should emphasize the delivery of benefits to the public, not only in the form of products and services, but also in U.S. leadership regarding the ethical conduct of research as well as the ethical use of technology.** With regard to the latter, the U.S. has long been an international leader, e.g., in the set of ethical principles for AI, which in May, 2019 was adopted by 42 OECD (Organization for Economic Cooperation and Development) nations<sup>43</sup>.

**Point #10. Don't Play to Not Lose.** For my final point, working at a university in which football is far more than a topic of casual conversation, I know well, as do others, that one does not win games by playing to not lose. Although S&T research and education are not games and are not about winning and losing *per se*, they are in fact influenced by the manner in which the U.S. develops its “game plans” and executes them, especially in the context of funding. **The U.S. is positioned, with development of the NSTS, to have a very strong and powerfully unique S&T game plan for the future, leading with its values, working with the international community, and investing wisely and boldly to ensure it remains the highest ship on the seas.**

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<sup>36</sup> <https://nap.nationalacademies.org/catalog/26647/protecting-us-technological-advantage>

<sup>37</sup> <https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/11/Summary-of-JCORE-Summit-November-2019.pdf>

<sup>38</sup> <https://trumpwhitehouse.archives.gov/presidential-actions/presidential-memorandum-united-states-government-supported-research-development-national-security-policy/>

<sup>39</sup> <https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/NSTC-Research-Security-Best-Practices-Jan2021.pdf>

<sup>40</sup> <https://www.whitehouse.gov/wp-content/uploads/2022/01/010422-NSPM-33-Implementation-Guidance.pdf>

<sup>41</sup> <https://orgchart.mit.edu/sites/default/files/reports/20221116-AssociateProvost-University-Engagement-with-China-final.pdf>

<sup>42</sup> <https://www.cogr.edu/sites/default/files/Version%20Dec%205%202022%20research%20security%20costs%20survey%20FINAL.pdf>

<sup>43</sup> <https://oecd.ai/en/ai-principles>

**Brief Biography of Dr. Kelvin K. Droegemeier**

Dr. Kelvin K. Droegemeier is Regents' Professor of Meteorology, Weathernews Chair Emeritus, and Roger and Sherry Teigen Presidential Professor at the University of Oklahoma, where he served for nearly a decade as Vice President for Research. He has been at OU for 37 years and co-founded and directed one of NSF's first Science and Technology Centers. He served two 6-year terms on the National Science Board, the last four years as Vice Chairman, nominated first by President George W. Bush and then by Barack Obama and confirmed both times by the U.S. Senate. He also served for two years as Oklahoma Cabinet Secretary of Science and Technology. Most recently, Dr. Droegemeier served for two years as Director of The White House Office of Science and Technology Policy (OSTP) and Science Advisor to the President. For two and a half months during this time, he also served as Acting Director of the National Science Foundation. His research involves numerical simulation and prediction of high-impact local weather, and the assimilation of data into storm-resolving models. He is a Fellow of the American Meteorological Society and the American Association for the Advancement of Science, and has published more than 80 referred journal articles and over 200 conference publications.

Chairman LUCAS. Thank you, Doctor.  
And Ms. Wince-Smith, you're recognized for 5 minutes.

**TESTIMONY OF MS. DEBORAH WINCE-SMITH,  
PRESIDENT AND CEO, COUNCIL ON COMPETITIVENESS**

Ms. WINCE-SMITH. Chairman Lucas, Congresswoman Bonamici, Members of the Committee, thank you for this opportunity to testify at this critical hearing on the U.S. science and technology enterprise, competition with China, and the need for a coordinated National Science and Technology Strategy.

The Council on Competitiveness's National Commission on Innovation and Competitiveness Frontiers comprises some 70 leaders across academia, industry, labor, and our national labs to really address these generational challenges facing our nature—Nation in order to drive our productivity, our standard of living, and our leadership in the world. To define the myriad competitiveness challenging our Nation and abroad, we've developed very actionable policy recommendations for the government and the private sector. And I want to share some of those with you today, as they clearly have informed the very seminal legislation that has been passed for our Nation and the future.

We know that we have entered a new age of innovation. It's defined by the convergence of these exponential disruptive technologies that are not only reshaping industries but really will determine the geopolitical and national security strength of nations, everything from the emergence of quantum platforms and autonomy, biofabrication, clearly precision agriculture. The list goes on, and the critical underlying importance of next-generation semiconductors and beyond lithium batteries.

While the U.S. is capitalizing on these unprecedented opportunities, we face so many major challenges in our enterprise from the decline in basic research investment, fewer Americans engaged in STEM and starting new businesses, longstanding barriers in the commercialization of the technologies that we invented here in America. China has stated its ambition to supplant the U.S. as the world's technological leader and become the dominant economic military geopolitical power to shape the foundation, the standards, and the rules of the new age of innovation.

If the U.S. fails to make the sustained large-scale investments in all our people, infrastructure writ large, we will not only stall economic growth, continue low productivity, fail to create the high-value jobs of the future, solve societal and environmental problems, and, very importantly, we will erode our geopolitical leadership, seriously damage our national security capabilities and power.

As noted, China's leaders openly state their long-term goal to supplant the U.S., including as the global leader of democracy and freedom. China's State-driven strategy is fundamentally different from that of the cold war era or the economic and industrial rise of Japan. And China is walking the talk, making massive investments in every strategic technology, as well as using, as we've heard from Chairman Lucas, the tools of intellectual property theft and aggressive cybersecurity attacks against our companies and our government.

China has targeted the entire semiconductor supply chain, as well as the batteries. Let's not forget that in the current generation of lithium batteries, 90 percent of the graphite is controlled and comes from China. They are aggressively acquiring U.S. tech startups and companies outside the jurisdiction of CFIUS (Committee on Foreign Investment in the United States).

So I have five recommendations I want to share quickly. One is that we do need new mechanisms for Federal coordination at the Cabinet level. And we have called for a White House National Competitiveness and Innovation Council, on the same par as the NSC (National Security Council) and the Economic Policy Council.

We are calling for expanding and investing in place-based innovation to develop a fully utilized, untapped potential of talent in our country, and upscaling a workforce, and forging of public-private investments and partnerships throughout our country, not just in the metropolitan cities and coastlines. We must integrate economic development and workforce development in the innovation hubs that are really possible for our Nation.

Three, we must embrace technology statecraft. That means working closely with our allies and partners in these critical technologies and doing so in a way that advances our shared interests, as well as expands trade, the global rules of trade, transparency, and ensuring more people in the world can participate in the benefits.

And then of course, we must scale and deploy our technology. We still have the proverbial valley of death. We need new financing models. Traditional venture capital will not get us where we need to be in dealing with next-generation semiconductors, batteries, and I know we're going to hear about laser energy fusion.

In closing, Mr. Chairman and Members of the Committee, we strongly support the full funding for the science components of the *CHIPS Plus Act* legislation. And I look forward to coming back soon as we have recommendations from the second phase of this national commission, which is being launched at the University of California (UC) in Davis. And I must say I'm very proud that Director Kim Budil is the Commissioner working with the council on developing the strategy for our Nation's future. Thank you very much.

[The prepared statement of Ms. Wince-Smith follows:]

**Testimony**  
**The Honorable Deborah Wince-Smith**  
**President & CEO**  
**Council on Competitiveness**  
**before the**  
**House Committee on Science, Space, and Technology**  
***United States, China and the Fight for***  
***Global Leadership: Building a U.S National Science and Technology Strategy***  
**February 28, 2023**

Chairman Lucas, Congresswoman Lofgren and members of the Committee, thank you for this opportunity to testify today on science and technology competitiveness with China and how the National S&T strategy can provide a vision and path forward for the U.S. research enterprise.

I have had the privilege to serve as president and CEO of the Council on Competitiveness since 2001. Before joining the Council, I had worked for over 20 years as a senior U.S. government official, including as the first Senate-confirmed Assistant Secretary for Technology Policy in the U.S. Department of Commerce and as an Assistant Director for International Affairs in the Reagan White House.

Since its founding in 1986 by former Hewlett Packard CEO John Young, the Council has been the nation's preeminent group of business, academic, labor, and national laboratory leaders shaping an impactful, bipartisan growth agenda for the United States – defining and calling for investments crucial to support the talent, technology, and infrastructure at the heart of U.S. prosperity.

The Council's work is grounded in the belief that despite the myriad of challenges that continue to ripple through the economy today, the United States' underlying strength as the global leader in innovation remains. However, we must develop and advocate for ever-evolving pathways to success in the 21st century.

Over the past three years, our work has been guided by our National Commission on Innovation and Competitiveness Frontiers. The Commission—comprised of almost 70 CEOs, university and college presidents and chancellors, national lab directors, and labor leaders—is working to both define the scope of the competitiveness challenge facing the United States, particularly from China, including persistent low productivity and its impact on U.S. citizens. The Commission will also develop a set of recommendations for a path forward to continued U.S. leadership across critical science and technology areas. The scope of the challenge and the path forward were most recently described in our report *Competing in the Next Economy*, and I'm pleased to share with you today important highlights from that work that are directly relevant to the Committee's work.

**A NEW AGE OF INNOVATION**

Now, in the third decade of the 21st century, America has entered a new Age of Innovation. Humanity is in the midst of the convergence and acceleration of the greatest revolutions in science and technology. A new phase of the digital revolution—characterized by vast deployment of sensors, the Internet of Things, and artificial intelligence—is making our physical world smart and generating the abundance of big data that is providing unprecedented levels of insight in nearly every domain and systems

optimization at every scale. Biotechnology and gene-editing have given humans the tools to manipulate the very “code of life,” nanotechnology the power to build things from the atom up, and autonomous systems to work without human hands, and watch the world and react without a human’s senses or intervention. Advanced computing, the big data revolution, and machine learning are accelerating research and transforming the tools of innovation, which will further propel discovery and new developments to new heights.

Each of these technologies and the innovations emerging from this deep ferment are just beginning to reveal their massive power and promise. They have numerous applications that cut across industry sectors, society, and human activities. And they are now converging on the global economy and society simultaneously, creating a new age of unparalleled knowledge and vast technological power—a new Age of Innovation—with profound implications for individuals, companies, for societies, nations, for the global community, and for U.S. economic and national security. These innovations are disrupting industries and business models around the globe, shifting labor markets, shaping the future, and altering the patterns of society and many dimensions of our lives. And by definition they are inherently dual use with profound economic and national security implications.

These technology-driven innovations also hold the potential to create solutions for some of humankind’s greatest challenges—providing adequate food and clean water for the world’s growing population, developing therapies to improve health and cure diseases, providing the clean energy needed to drive economic opportunity in developing and underdeveloped countries, and mitigating climate change and environmental problems that threaten our planet. New technology-based tools will open greater access to learning everywhere, further democratizing innovation and its benefits globally.

At the same time the United States faces an unprecedented opportunity for progress, it also must confront a set of new competitive realities. New knowledge, new technological advancements, and the capital and skills needed to transform this knowledge and technology into innovations, products, and services for the world are now all highly mobile—and more than ever before in history, many countries around the world have access to any of these resources. As result, game changing technologies and innovations now originate almost anywhere, and nations around the world seek to leverage these resources for global competitive advantage and economic gain. Among these nations, a rapidly strengthening China seeks global technology leadership as part of its quest to become the world’s economic, military, and geopolitical leader and shaper of the foundational rules for the “next” global economy.

U.S. leadership in technology-based innovation and our long-term competitiveness are under threat. As a nation’s ability to innovate becomes ever more fundamental to its competitiveness and economic success, the very foundations of the U.S. capacity and capability in science and technology are eroding. There are deficiencies in the U.S. innovation engine, and barriers in developing and scaling new technologies. And, the United States has entered the third decade of the 21st century with too few of its citizens equipped with the knowledge, skills, and opportunities to participate and thrive in an ever more innovation-driven economy.

There are many examples I could point to highlighting the challenges of bringing more Americans into the innovation economy, but if you think of the country as a team, we are leaving far too many players and regions on the bench. This is true geographically and demographically. One example being the inadequacy of post graduate compensation as a barrier to more Americans, especially those from low

socio-economic backgrounds, pursuing graduate STEM degrees. This issue has been echoed by the National Science Board who pointed out that we will not reach the “missing millions” of Blacks, Hispanics, American Indians, Alaska Natives, Native Hawaiians, and women who are underrepresented in STEM, if we don’t address compensation and student debt, as well as the ever-escalating cost of higher education, in general.

How the United States and its leaders respond to the duality of this new age—unprecedented prospect for progress and prosperity on the one hand, and clear and present dangers at home and abroad on the other hand—will have profound implications for generations to come. If United States does not mount a strong all-of nation response to these opportunities and new competitive realities at home and from overseas, if we fail to make needed investments in our people and future, our nation’s fundamental capacity to grow its economy, create jobs, maintain national security, solve societal challenges, and provide a social safety net will continue to erode, and our geopolitical leadership will be at increasing risk.

#### CHINA’S RISE

*We will increase investment in science and technology through diverse channels and strengthen legal protection of intellectual property rights, in order to establish a foundational system for all-around innovation.* - President Xi Jinping, Report to the 20th National Congress of the Communist Party of China October 16, 2022

In short, China seeks to supplant the United States as the world’s technological, economic, military, and geopolitical leader. The United States has faced formidable strategic competitors in the past. During the Cold War, the Soviet Union sought military supremacy, but could not secure global economic and market leadership. During the 1980s, Japan sought commercial market dominance, but not military superiority. China seeks both.

To achieve its superpower goals, China seeks to build a science and technology capability rivaling the size and breadth of the U.S. capability. It seeks to create the mechanisms to innovate—commercializing its growing achievements in science and technology—and sees business enterprises as playing the prime role. The government’s role involves overall planning, and promoting the linking of capital, technology, and markets. China recognizes the gap between basic research and technology commercialization, and states that government will work to resolve this connection problem.<sup>i</sup>

With the objective of dominating the next generation of innovation, China is pursuing aggressive plans for every strategic critical underlying technology, backed by commitments for hundreds of billions of dollars in investment. For example, the Made in China 2025 initiative, announced in 2015, seeks to transform China from a manufacturing giant into a global science and technology power by 2049 (the 100th anniversary of the People’s Republic of China), while it set a target to become one of the most innovative countries by 2020 and a leading innovator by 2030.<sup>ii</sup> In one example, it was just announced that China has filed more patents than the U.S. for nuclear fusion technology.

Made in China targets advanced IT, advanced machine tools, robotics, aerospace technology, maritime equipment, new energy vehicles, biomedicine, advanced medical equipment, and importantly battery technology, including all aspects of the supply chain.<sup>iii</sup> China is targeting development of the entire

semiconductor ecosystem, including spending of more than \$150 billion over 10 years for investments and acquisitions, which makes the \$52 billion Congress included in last year's CHIPS Act seem both necessary and inadequate at the same time.<sup>iv</sup>

In August 2020, the Chinese government updated its semiconductor policy to emphasize foreign academic and industry collaboration (including domestic and overseas R&D centers), expanding China's role in developing international rules for protection of intellectual property, advancing Chinese standards, use of antitrust authorities, and priority financing vehicles.<sup>v</sup> China's semiconductor policies include a strong government role in directing and financing Chinese businesses to obtain foreign intellectual property related to semiconductors.

In another example, in 2010, China made a major move in life sciences research when its company BGI purchased 128 of the world's fastest gene sequencers, half the global capacity for gene sequencing at that time. Today, China accounts for 30 percent of the world's sequencing capacity.<sup>vi</sup> In a recently translated speech, Chinese President Xi Jinping emphasized that China must place greater emphasis on basic research in heredity, genetics, virology and related fields; accelerate R&D and technological innovation of related drugs and vaccines; and elevate the importance of applying information and data technologies to these fields.<sup>vii</sup> It plans to support the establishment of a cellular genetics and genetic breeding technology R&D center, a synthetic biotechnology innovation center, and a biotech and pharmaceutical innovation Center to accelerate the pace of innovation and development for the biotech industry

And, in September 2020, the Chinese Communist Party Central Committee and State Council released Guiding Opinions on Expanding Investment in Strategic Emerging Industries and Cultivating Strengthened New Growth Points and Growth Poles.<sup>viii</sup> The guidance is focused on economic and social development, including accelerated promotion of strategic emerging industries and industrial clusters. It calls for building out the ecosystems, supportive financing mechanisms, and investment in technology development, demonstration, and deployment across Chinese industry and society of every strategic critical technology. This includes technologies and industries pioneered and dominated by the United States, ranging from biotechnology to the digital creative industry.

China is deploying a multi-pronged strategy to acquire technologies and intellectual property from other countries by both licit and illicit means. I've seen this firsthand as a member of the Commission on the Theft of American Intellectual Property. This includes building research centers in U.S. innovation hubs, forming partnerships with U.S. research universities, forced joint ventures for market access, sending students to the United States for academic studies, cyber theft, and industrial espionage. To absorb foreign technologies, authorities have established engineering research centers, enterprise-based technology centers, state laboratories, national technology transfer centers, and high-technology service centers.

The U.S. Trade Representative reports that China has engaged in a range of unfair and harmful conduct, including investment and other regulatory requirements that require or pressure technology transfer, and direction or facilitation of the acquisition of foreign companies and assets by domestic firms to obtain cutting-edge technologies.<sup>ix</sup>

There is also growing concern about China's presence on U.S. college campuses. In 2021-22, there were more than 294,000 Chinese foreign nationals studying at U.S. colleges and universities, almost one-third

of all foreign students.<sup>v</sup> Many of these students are in U.S. science and engineering graduate programs. Most do not have visas to stay in the United States and will return to China. Chinese companies seek research partnerships with U.S. universities and are setting up research centers in the United States to access U.S. talent and technology. State-backed Chinese enterprises increasingly finance joint research programs and the construction of new research facilities on U.S. campuses.

China's talent recruitment programs are also raising red flags. These programs target U.S.-based and other researchers around the world who focus on or have access to cutting-edge research and technology. In recent years, federal agencies have discovered talent recruitment plan members who downloaded sensitive electronic research files before leaving to return to China, submitted false information when applying for federal grant funds, and willfully failed to disclose receiving money from the Chinese government on federal grant applications. In some cases, talent program members received both U.S. grants and Chinese grants for similar research, established "shadow labs" in China to conduct parallel research, and stole intellectual property.

Lastly, China is seeking to shape large swaths of the 21st century global economic and trading system. It has been using its growing role in multilateral institutions and in the global trading system to advance its mercantilist dominance, including deploying a debt-financed development infrastructure model in other countries, as the United States' international engagement has atrophied. For example, China's Belt and Road Initiative is staggering in scope, a new Silk Road of railways, energy pipelines, highways, shipping lanes, and special economic zones, fueled by \$1 trillion in Chinese investment, and in recent years the aggressive acquisition and control of strategic ports around the world most recently Haifa in Israel. The initiative would touch more than 4 billion people, 65 countries, and \$23 trillion in GDP.<sup>vi</sup>

Through Belt and Road, China is massively financing, constructing, gaining ownership, and operating critical infrastructure around the globe, including a new "Digital Silk Road." It seeks to transform global infrastructure in its model, and shape digital infrastructure and connectivity.

#### **THE PATH FORWARD FOR U.S. LEADERSHIP**

Of the hundreds of potential recommendations the Council compiled for its 2020 report, we identified 50 priority recommendations that were:

- (1) urgent—failure to act could create serious consequences for the United States;
- (2) strategic—they are fundamental to U.S. economic and national security; and
- (3) pivotal—they could play a prime and determining role in the scope and rate of U.S. innovation.

The bottom-line is simple—to compete in the next economy requires playing a new innovation game, one whose goal is to boost U.S. innovation tenfold: 10x. The call-to-action from the Council on Competitiveness and its National Commission on Innovation and Competitiveness Frontiers—for local, state and national policymakers to come together with the private sector to focus in a bold and transformational way on all efforts to optimize the United States for a new, unfolding, challenging innovation reality.

While I commend the full *Competing in the Next Economy* report to you, I want to highlight for you today five specific steps I think are critical to our nation's success and should be part of a National Science and Technology Plan.

### Federal Coordination at the Cabinet Level

There are many factors that affect a county's ability to innovate and compete. These include: investment in research and development; the availability of capital for innovation at critical stages; the access to and provision of education that develops a growing base of qualified, diverse, innovation-prepared talent; the ecosystem for entrepreneurship; and the general business environment including taxes, fiscal policy, trade policies, and business regulation. In addition, how these factors affect innovators and business can vary depending on company size, whether in an infant or mature industry, capital or labor intensity of the industry, services or manufacturing, and the life-cycle of technologies and products in the industry.

To address these diverse factors, some U.S. competitors have established high-level ministries, government departments, or other organizations devoted to stimulating technology and innovation and to guide national strategic plans. In the past, the United States has had federal entities that addressed the scope of issues and factors that affect innovation and competitiveness, and sought to better integrate the federal leadership role in program coordination, analysis, and policy development. Also, Congress had an Office of Technology Assessment that performed critical studies to advise Congress on the role of technology in the economy and society. However, these entities did not survive changes of Presidential Administrations, reached sunsets as provided for in their authorizations, or were eliminated as budgetary saving measures.

As a result, the United States does not have in the federal government a single leadership structure for U.S. innovation and competitiveness, and related capacity and capabilities. Instead, policy formulation is fragmented as responsibility for addressing the factors that affect innovation and competitiveness cuts across many stove-piped missions of federal departments and agencies, multiple bodies within the Executive Office of the President, competing Presidential Cabinet-level councils, and multiple Congressional committees.

The closest integrative bodies are the National Economic and Domestic Policy Councils. The White House Office of Science and Technology Policy's scope of work revolves largely around federal science and technology policy, and federal R&D investment and programming. However, many critical policies having an impact on the Nation's innovation capacity and outcomes are within the purview of other White House bodies, such as the Council of Economic Advisors, the Office of Management and Budget, the National Security Council, etc.

In contrast, for example, the President's Commission on Industrial Competitiveness of the 1980s—the precursor to the Council on Competitiveness—addressed a range of issues in addition to research and technological innovation, including global trade policy, tax policy, patient capital, intellectual property protection, manufacturing modernization, and regulation. Similarly, broader in scope, the Stevenson-Wydler Technology Innovation Act of 1980 and its amendments—one of the major legislative initiatives in technology and innovation, guiding the government role for decades—outlined the scope of responsibilities vested in the leadership organization at the U.S. Department of Commerce.<sup>40</sup> Under these and follow-on authorities, the Commerce Department carried out a diverse range of activities related to competitiveness and innovation.

In today's even more complex and turbulent innovation environment, domestic and global, the federal government must elevate the innovation agenda to the highest levels of decision-making. The United

States needs a permanent, high-level, adequately and continually funded and staffed organization to lead national efforts to leverage new technology, and strengthen U.S. innovation and competitiveness, given their fundamental role in economic growth, job creation, and societal functioning.

The federal government should establish in the Executive Office of the President a National Competitiveness and Innovation Council (NCIC), with status similar to the National Security Council (NSC) and National Economic Council (NEC).

And an important mission of the National Competitiveness and Innovation Council is the establishment of a competitiveness and innovation intelligence and assessment program—in essence, an innovation radar for the Nation. The innovation radar initiative could:

- Identify, monitor, and analyze information on key U.S. competitors' major initiatives, policies, and programs to boost national innovation and competitiveness, develop and publish reporting of findings as appropriate, and apply what is learned to improve U.S. policies and efforts.
- Conduct special "deep dive" studies to provide further insight on the U.S. position, its strengths, weaknesses, and vulnerabilities.
- Assess U.S. global competitors along a continuum of competitive strength, including a view from a critical industry and critical technology perspective. In addition to the current competitive situation, create an early warning capability to signal and monitor competitor strengthening and capabilities building that could be realized in the decade ahead, and potentially challenge the United States in critical emerging technologies and innovations of importance. The goal would be to prompt the United States to take steps to ensure it is not over-matched in the future.

#### **Expand and Fund Place-based Innovation Efforts**

As competition in the global innovation landscape intensifies, there is a growing urgency to capitalize on untapped talent across America. Innovators in Silicon Valley and other coastal hubs have helped position the United States as a science and technology leader, but many communities and regions have yet to fully join, engage in, and benefit from the country's innovation economy. The innovation workforce is highly concentrated in major metropolitan areas, with the top five metro areas—Boston, San Francisco, San Jose, Seattle, and San Diego—accounting for more than 90 percent of the nation's innovation-sector growth from 2005 to 2017.<sup>xiii</sup> The costs of this hyper-concentration are playing out in real time. Coastal technology clusters are increasingly facing congested transportation, skyrocketing costs of living, and constrained housing, while lagging regions are excluded from participating in or benefiting from American innovation.<sup>xiv</sup>

To remain competitive in the next economy, the United States must expand its innovation footprint. Broadening the U.S. innovation ecosystem—which is a system of systems, rather than monolith—will require targeted efforts that meaningfully engage different communities and diverse populations as beneficiaries, workers, innovators, and entrepreneurs. Effective place-based innovation strategies that involve and engage a much broader swath of Americans in the innovation future can help to support U.S. science and technology leadership for decades to come.

The challenges and barriers facing the innovation landscape differ by geography, as do the unique opportunities presented by distinct assets, knowledge, and resources in each region. "One-size-fits-all" approaches to supporting regional innovation ignore these crucial geographic distinctions and fail to

capitalize on different regions' core competencies and advantages. Meanwhile, communities in certain regions often lack the resources and strategic guidance needed to gear up local innovation and ultimately compete against each other for talent and capital.

Finally, research has found that traditional place-based policies often create a zero-sum game that merely shift workers and firms from one area to another without increasing overall economic activity.

The United States must recognize the unique capabilities, resources, and competitive advantages present in every region and take active steps to include all corners of the country in its innovation future. Important steps have already been taken with passage of the CHIPS and Science Act last year laying the groundwork for the expansion of tech hubs. Still, the nation needs a coordinated national strategy for place-based innovation to help leadership in underutilized regions identify and leverage their local niche. Part of that strategy should include establishing regional centers dedicated to innovation fields that align with the specialized expertise, capabilities, or natural resources specific to the area.

Many regions across the country are already experimenting with novel place-based innovation strategies that seek to develop regional assets and leverage competitive advantages. For example, Oak Ridge National Laboratory—partnering with key regional stakeholders, including industry and universities—is finding new ways to turbocharge its regional economy, to provide students access to unique laboratory resources, and attract top-tier talent. This experimental evolution in place-based policies is likely to grow as regions coordinate and collaborate across longer distances in an increasingly digitized national innovation ecosystem.

And many universities across the country are building a more diverse STEM workforce and leveraging their role as drivers of regional economic revitalization, such as South Dakota State University and Morgan State University in cyber, Oklahoma University for hypersonics, and Kansas State University on biodefense, just to name a few examples.

Furthermore, the innovation economy suffers from a lack of socioeconomic and racial diversity. White children are three times more likely to become inventors than black children, and children with parents in the top 1 percent of the income distribution are ten times more likely to file a patent than children with below-median income parents.<sup>17</sup> While these disparities indicate an extreme challenge, they also present a real opportunity.

The United States should engage underserved communities in its efforts to establish new centers of regional innovation and economic growth. Research shows that exposure to innovation is the greatest driver of innovative capacity, but many of these communities lack this crucial exposure.<sup>19</sup> Embedding innovation in local school curricula, business skills training, and community programs will be a key step towards inspiring future innovators and revitalizing struggling communities. By offering educational and employment opportunities to community members, America can activate enormous untapped innovation potential.

#### **The U.S. Must Embrace Technology Statecraft**

As noted, the United States currently lacks a cohesive national strategy or dedicated federal body for advancing U.S. innovation and competitiveness. Importantly, domestic innovation leadership must be coupled with increased engagement on the international stage. The Council is strategically deepening

our collaborations with like-minded allies and leading tech nations such as the UK, Australia, Japan, and the bipartisan Quadrilateral Security Dialogue (U.S., Australia, India, and Japan). And finally, through the work of our sister organization, the Global Federation of Competitiveness Councils.

Technology is the driving force of the 21st-century global economy. Nations are mobilizing to capture their share. These countries work to strengthen their technology and innovation capabilities by influencing international economic, scientific, trade, and security institutions and arrangements. In recent years, though, the United States has put shaping the 21st-century economy on the backburner, and China has stepped into the vacuum. China is moving aggressively to assert leadership and shape the direction of global rules and institutions.

China announced it will set up a United Nations Global Geospatial Knowledge and Innovation Center, as well as International Research Center of Big Data for Sustainable Development Goals. Four of the 15 U.N. science- and technology-related agencies are now led by China; in contrast, the United States leads one. The United States also had to mobilize key allies to deny China — the world's top threat to intellectual property (IP) — leadership on the World Intellectual Property Organization, the global guardian of IP.

By increasing China's profile on international standards bodies, it aims to implement the nation's China Standards 2035 blueprint and Belt and Road Initiative, with the aim of influencing standards for next-generation technology such as advanced microchips, the internet of things, cloud computing, big data, 5G, intelligent health care, and AI.

Regardless of whether it's our foes, such as China, or allied counterparts, such as the European Union, the international community is upping its game and diminishing the reach and impact of American innovation, influence, and opportunity. We can't afford to fall behind any further. The United States must play a more muscular role in the international arena to defend its global competitiveness. We need to ensure that rules for governing technology and competition, as well as the flows of goods, services, and data in the next economy are shaped by liberal, democratic, and free market principles.

The United States must elevate the use of technology statecraft in U.S. economic and national security strategy. By focusing U.S. government actions on international rules, institutions, arrangements, deployment of capital and scientific resources, we can engage in mutually beneficial collaboration with likeminded foreign partners that share American values and interests in shaping rules for the 21st-century economy. This includes: international coordination on cross-border investment with national security implications; more robust U.S. participation in international scientific institutions and in international financial institutions affecting competitiveness; U.S. priority to new international rules for the digital economy; more partnering and collaboration on R&D with strategic allies; and, integrating science, technology, and innovation into our core diplomatic and foreign service capability - for example, building a new U.S. International Science, Technology, and Innovation Corps to substantially increase the number of Americans in these fields serving as foreign service officers, in the Foreign and Commerce Service, and as trade negotiators.

Just as China has a whole-of-government approach, we must take a similar one to achieve our national science and technology goals as its personnel carry out its foreign political, national security, and commercial engagements around the world. If we do not counterbalance the Chinese Communist Party's aggressive ambitions and moves in reforming the global governance system, we will be

challenged to constrain its authoritarian, anti-competitive, and illicit practices — and the competitiveness and economic security of many nations, including our own, will be under threat.

#### **Developing and Deploying Technology at Scale**

Throughout the 20th century, some U.S. corporations operated large, free-standing centralized industrial research laboratories that developed inventions and applications in response to real world problems, possibilities, and user needs. These laboratories housed specialized equipment and facilities to test and validate inventions and applications, and they were institutionally connected to integrated production facilities, simplifying the flow of new applications to production with no technology transfer gap or valley of death.

Corporations have refocused their technical efforts largely to product development. With few exceptions, the United States no longer has large, multidisciplinary-staffed industrial labs connecting broad areas of research and technology to problems and market possibilities. This has left the United States with a weaker capability to translate new technology developments into applications and economic impact. One exception is the large multidisciplinary laboratories run by some federal agencies, such as those at the Departments of Energy and Defense who are increasingly engaging strategically with companies, universities, and the start-up ecosystem. However, while similar in scale, scope, and capabilities of old industrial research laboratories, these laboratories are focused on achieving their government missions. Another exception are several large high-tech hubs on the coasts of the United States, which are world leaders in scaling applications in the digital and biotechnological domains. These hubs are anchored by large companies and/or top research universities or institutions. They are also start-up generators, but start-ups do not have the resources to bring their technologies to scale.

Now, with few exceptions, the U.S. innovation ecosystem is mostly broadly divided into two large research and innovation sectors:

- Academic research at universities, largely agglomerations of single-discipline, investigator-driven, small scale basic and exploratory research focused on discovery and knowledge generation.
- Product development in private companies

This division of labor has created a “missing middle” in applications research, where invention occurs and innovation begins. It has also resulted in a time-consuming technology transfer gap (when new discoveries or technologies are “transferred” to the private sector), and the valley of death (in which immature technologies emerge from universities or start-ups but they do not have the resources to de-risk them to make them more attractive for private sector investment and commercialization). In addition, most STEM students are trained to work in an academic research setting even though most will work in the private sector.

To fill this missing middle—in attempts to stimulate the transfer of university research to the private sector for commercialization, and close the valley of death—the United States has established numerous research initiatives, institutes, etc. However, they can be: diffuse, fragmented, and distributed; relatively small in scale; limited in their disciplinary domain, and; often disconnected from specialized equipment for testing and verification.

With few exceptions, such as the 15 Manufacturing USA institutes, they operate at arms-length from industrial production, the marketplace, and real-world problems. A new model of R&D organization that focuses and helps integrate the efforts of all parts of the innovation enterprise could help fill that missing middle. These entities—which could be institutes, consortia, smaller research and application centers, or hubs—should be distinct from, but complement the efforts at national laboratories, basic research at universities, and other institutes and initiatives.

With funds from an expanded public investment in R&D, the federal government should co-fund with industry several pilot at-scale initiatives to demonstrate new models of application-oriented R&D efforts with the above-mentioned characteristics. These should be selected based on a rigorous competition taking into account industry commitment, technical capability and capacity, opportunity landscape and potential for economic impact, and adequacy of supporting ecosystem elements.

The scope of the challenge will also require entirely new financing models beyond traditional venture capital such as a national infrastructure bank.

#### **IN CLOSING – A CALL TO FUND THE “SCIENCE” IN CHIPS AND SCIENCE**

I realize this is an appropriations issue and this Committee is to be commended for its leadership and support of increased federal science authorizations. Nonetheless, I would be remiss if I did not specifically call out the importance of fully funding the science provisions in the CHIPS and Science Act signed into law last year.

As I have detailed today, the United States faces global challenges and competition across the scientific, research, and innovation landscapes greater than we’ve ever seen before. China’s share of global research and development has quadrupled over the past two decades and its investment in research has more than doubled. At the same time, U.S. investment has lagged in comparison to global competitors now ranking tenth as a percentage of GDP.

It is this global competitive reality that spurred Congress to act in a bipartisan manner and it is why the legislation includes \$52 billion in emergency spending to bolster the U.S. semiconductor industry, so desperately needed to support U.S. economic leadership and national security. I know Congress provided significant increases in funding, but even those increases fell short of the authorized investments.

In this town, and especially within the S&T community, we often refer to major challenges as being “Sputnik moments” requiring generational responses. But so often those responses while loud in the moment, fade with time and become incremental rather than game-changing. I urge you not to let that happen with the funding envisioned for science and technology in the CHIPS and Science Act.

The Council is continuing its focus on competitiveness with the launch of the second phase of our Commission’s work. We know we need new models and new ways of collaborating to meet the moment. Our business leaders, academic leaders, labor leaders and national lab directors are committed to finding the path forward for the United States to ensure continued opportunity and prosperity for all Americans.

Thank you.

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<sup>i</sup> Speech on Certain Major Issues for Our National Medium- to Long-term Economic and Social Development Strategy, President Xi Jinping in April 2020 (translated), Center for Security and Emerging Technology, and Etcetera Language Group, November 10, 2020.

<sup>ii</sup> China's Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable A Strategic Competitor to Access the Crown Jewels of U.S. Innovation, Defense Innovation Unit Experimental,

<sup>iii</sup> *Made in China 2025: Global Ambitions Built on Local Protections*, U.S. Chamber of Commerce, 2017.

<sup>iv</sup> *Made in China 2025: Global Ambitions Built on Local Protections*, U.S. Chamber of Commerce, 2017.

<sup>v</sup> China State Council, "Notice on Issuing Several Policies to Promote the High-Quality Development of the Integrated Circuit Industry and the Software Industry in the New Period," August 4, 2020.

<sup>vi</sup> 2018 Global R&D Funding Forecast, R&D Magazine, Winter 2018.

<sup>vii</sup> Speech on Certain Major Issues for Our National Medium- to Long-term Economic and Social Development Strategy, President Xi Jinping in April 2020 (translated), Center for Security and Emerging Technology, and Etcetera Language Group, November 10, 2020.

<sup>viii</sup> Translation jointly produced by DigiChina, Stanford University Cyber Policy Center, in partnership with New America and the Center for Security and Emerging Technology at Georgetown University.

<sup>ix</sup> Findings of the Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974, Office of the United States Trade Representative, March 22, 2018.

<sup>x</sup> OpenDoors Report on International Education Exchange, U.S. Department of State and Institute of International Education.

<sup>xi</sup> Center for Strategic and International Studies, China Power Project.

<sup>xii</sup> This scope included: determining the relationships of technology developments to U.S. economic performance; determining the impact of economic and labor conditions, industrial structure and management, and government policies on technological developments in particular industrial sectors; identifying technological needs, problems, and opportunities within and across industrial sectors; assessing the adequacy of capital and other resources being allocated to domestic industrial sectors which are likely to generate new technologies; proposing and supporting studies and policy experiments to determine the effectiveness of measures with the potential of advancing United States technological innovation; and considering government measures with the potential of advancing United States technological innovation.

<sup>xiii</sup> Brookings (2019), "The case for growth centers: How to spread tech innovation across America."

<sup>xiv</sup> Kenan Institute of Private Enterprise (2021), "Is Big Tech Headed for a Big Tumble?"

**Deborah L. Wince-Smith  
President & CEO  
Council on Competitiveness**



The Honorable Deborah L. Wince-Smith is the President & CEO of the Council on Competitiveness, a non-partisan leadership coalition of CEO's, University Presidents, Labor Union Leaders, and National Laboratory Directors, all committed to developing policy solutions and national initiatives to drive future productivity growth, prosperity for all Americans, and the global success of American business. She has more than 20 years of experience as a senior U.S. government official, as the first Senate-confirmed Assistant Secretary for Technology Policy in the U.S. Department of Commerce in the Administration of President George H.W. Bush, and as the Assistant Director for International Affairs in the White House Office of Science and Technology Policy in the Reagan Administration. She served as a Senate confirmed member of the Oversight Board of the Internal Revenue Service in the Administrations of President George W. Bush and President Barack H. Obama.

As a globally recognized leader and practitioner in competitiveness strategy, innovation policy, technology commercialization, and public-private partnerships, Ms. Wince-Smith has served and is a current member on numerous national and global advisory boards and committees, as a University Trustee, and as a director on public and private corporate boards.

She has served on the University of California's President Council for the National Laboratories, the Board of Governors of Argonne National Laboratory, the US Naval Academy Foundation, the Smithsonian National Board, as a Trustee of Lehigh University, member of the Advisory Committee of the US Export-Import Bank, UNICEF, the Secretary of State's International Economic Policy Committee, as Chair of the Secretary of Commerce's Strengthening America's Communities Initiative (SACI), Chair of the World Economic Forum's Global Agenda Council on Competitiveness, member of Malaysia's Global Science and Innovation Advisory Council (GSIAAC), and as a Corporate Director of NASDAQ-OMX.

Currently, Ms. Wince-Smith serves as a Commissioner on the Council on Competitiveness National Commission on Innovation and Competitiveness Frontiers, the National Commission of the Theft of American Intellectual Property, a Council Member of the Japan Science, Technology, and Society Forum (STS), as a member of the Global Advisory Committees of the Japan Science and Technology Agency (JST) and the Delphi Economic Forum (DEF), the National Academies Strategic Council on Research Excellence, Integrity, and Trust, as Vice-Chair of the Trustees of the American College of Greece (ACG), the Strategic Research Advisory Committee of the University of Oklahoma, the advisory committee of Queen's Management School, Queen's University Belfast, and as a Director of private technology companies in medical lasers, cybersecurity, and bio-therapeutics.

Born in Akron, Ohio, Ms. Wince-Smith graduated Valedictorian from Old Trail School. Ms. Wince-Smith graduated magna cum laude and Phi Beta Kappa from Vassar College and earned a master's degree in Classical Archaeology from King's College, Cambridge University. She has received Honorary Doctorates from Michigan State University, the University of Toledo, the Queens University Belfast, Worcester Polytechnic Institute, and the University of South Carolina.

Chairman LUCAS. Thank you.  
And Dr. Budil, you are recognized for 5 minutes.

**TESTIMONY OF DR. KIM BUDIL,  
DIRECTOR, LAWRENCE LIVERMORE NATIONAL LABORATORY**

Dr. BUDIL. Thank you, Chairman Lucas, Congresswoman Bonamici. I'd like to extend my regards and thanks also to Congresswoman Lofgren for her long-term partnership and support, and Committee Members. I'd like to thank you for the opportunity to testify today and for the Committee's commitment to ensuring U.S. scientific and technical leadership.

I'm the Director of the Lawrence Livermore National Laboratory, a Department of Energy (DOE) National Nuclear Security Administration (NNSA) lab, dedicated to applying leading-edge science and technology to address the most important security challenges facing the Nation and the world. I also chair the National Laboratory Directors Council, where I represent colleagues from across the DOE, which is home to 17 national laboratories, again, three of which are overseen by the NNSA, Lawrence Livermore, Los Alamos, and Sandia National Laboratories.

These labs are home to many unique scientific tools, and we work across the full spectrum from fundamental discovery science, often in partnership with academia, to applied science and technology for ultimate transfer to industry for deployment. Together, these world-class national labs are strong contributors to and enablers of U.S. leadership in science and technology.

On December 5, researchers at the National Ignition Facility at LLNL achieved fusion ignition in the laboratory for the first time in history. This achievement was six decades in the making. As we consider U.S. innovation ecosystem today, it's reasonable to ask what made this work. Ignition is a remarkable scientific advance, but it's also a triumph of sustained and patient support for research from Congress. This enduring support has made the DOE national laboratory system the envy of the world due to its world-class workforce and formidable scientific capabilities. Fusion ignition also demonstrates to the world our Nation's capabilities and, importantly, ensures that the U.S. has the best people and ideas to bring to bear on the important challenges that we face as a Nation.

The ignition story also highlights the important role that the national labs play in the U.S. S&T ecosystem. Chartered as Federally Funded Research and Development Centers (FFRDC), the national labs have enduring missions and are well-positioned to foster collaborations with academia, industry, and international partners to tackle the biggest, most important challenges. The national labs are skilled at bringing together multidisciplinary teams and expert in designing and building state-of-the-art large-scale scientific facilities, often unique in the world.

The National Ignition Facility was built as a centerpiece facility for the Stockpile Stewardship Program for which it has made highly impactful contributions in ensuring the safety, security, and reliability of our Nation's nuclear deterrent. NIF has enabled fundamental discoveries as well, ranging from novel material properties to astrophysical phenomena, and decades of research on lasers and

optics have led to remarkable advances. For example, national lab R&D led to extreme ultraviolet lithography that has enabled production of microchips that power the newest iPhones, and adaptive optics technologies that dramatically enhance the capabilities of ground-based telescopes. The national lab environment creates opportunities for innovations not always foreseen that serve the U.S. extremely well.

So what does the future hold? I have high confidence that the Lawrence Livermore team and collaborators can continue to increase fusion yields, which are needed for our national security mission, as well as potential energy applications. To advance inertial confinement fusion for energy, we need to create new kinds of partnerships, and several of my fellow witnesses have commented on the importance of creating a vibrant partnership ecosystem. Without significant public support for fusion energy research, the labs will not be able to build partnerships to support a rapidly growing private sector fusion energy enterprise with vitally needed unique facilities, capabilities, and expertise. And, as of last tally, there was about \$5 billion in private capital being put into fusion energy companies across the many approaches. Without robust public sector investment, that capital will not realize the potential that it represents.

I'm often asked what the timeline is for fusion energy on the grid, but perhaps a better question is what will it take to make that timeline short enough to meet the urgent need for this technology?

With that, I look forward to your questions, and thank you again for the opportunity to testify.

[The prepared statement of Dr. Budil follows:]

House Science, Space & Technology Committee Testimony  
LLNL Director Dr. Kimberly Budil  
February 28, 2023

## INTRODUCTION

As the Director of Lawrence Livermore National Laboratory (LLNL), I thank the Committee for the opportunity to testify and for the Committee's role in and dedication to ensuring U.S. scientific and technical leadership. As a National Nuclear Security Administration (NNSA) laboratory, LLNL is a proud member of the Department of Energy's network of national labs working to make the world a safer place through science and technology (S&T).

This year, I am also serving as the Chair of the National Laboratory Directors Council, and I'm honored to represent my fellow Department of Energy (DOE) Laboratory Directors here. There are 17 national labs in the DOE system, three of which are overseen by the NNSA: Lawrence Livermore, Los Alamos, and Sandia. Together, these world-class national laboratories are strong contributors and critical enablers of U.S. S&T leadership.

LLNL was established in 1952 to pursue audacious ideas through team science. Last year, LLNL celebrated our 70th Anniversary with the theme "Making the Impossible Possible," a mantra that came to life with the achievement of fusion ignition. I will use this recent success—which has been widely compared to the first flight by the Wright brothers—to illustrate key points I wish to make on federal investments to sustain United States leadership in critical areas of S&T.

## KEY POINTS

### **U.S. leadership in Science and Technology matters.**

Staying at the forefront of science and technology (S&T) matters for national security and economic competitiveness, which are at stake in an increasingly competitive and dangerous world. The leadership in S&T that the national labs have demonstrated shows what we are capable of – as with the breakthrough experiment on National Ignition Facility in December. We are challenged to ensure we continue to bring the best new ideas, capabilities, and people to bear on important national security challenges.

### **Establish national long-term S&T priorities and sustain investments toward meeting goals.**

Federal investments in S&T are guided by national policy, such as that articulated in the 2020 National Strategy for Critical and Emerging Technologies (C&ET) and 2022 Updated List of C&ETs. Innovation and the sustained support of Congress are required to attain long-term objectives. The DOE national labs are well positioned to provide innovative solutions to pressing national needs; this is especially true for the NNSA national security laboratories. LLNL has mission responsibilities in Nuclear Deterrence, Threat Preparedness and Response, Climate and Energy Security, and Multi-Domain Deterrence. We execute programs ranging from nuclear weapons, biosecurity, and WMD nonproliferation to cyber and space security, infrastructure reliance and climate change, and advanced conventional weapons technologies.

**National laboratories are critical enablers of U.S. S&T leadership.** Established to meet the special long-term research and development needs for the nation, the system of DOE national laboratories are leading institutions for scientific innovation. The labs tackle critical scientific challenges and possess unique instruments and facilities. They address large scale, complex R&D challenges with a multi-disciplinary approach, working with academia on basic science collaborations that provide opportunities for student training and with industry to develop innovative solutions in support of national priorities. Federal investments in national labs—to support top-notch staff and outstanding scientific capabilities—have provided the foundation of U.S. S&T leadership since the end of World War II. Continuing these investments is crucial for future U.S. S&T leadership.

**Public-private partnerships are critical to ensure U.S. excellence in S&T.** The DOE national laboratories partner to leverage expertise and develop innovative solutions to grand scientific challenges. Frequently, several DOE laboratories partner as a synergetic team to apply the unique strengths, expertise and capabilities of each lab to grand challenges. The labs also combine forces and capabilities with industry and academia for national benefit. For example, DOE user facilities provide unique capabilities to academia, which helps accelerate scientific discovery and provides a pipeline to train scientists, some of whom are attracted to join the DOE lab workforce. Collaborations with industry have, for example, led to U.S. predominance in high-performance computing (HPC). It is the effective teaming together of the U.S.'s unique national laboratory system, world leading academic institutions, and industrial prowess that enables America's leadership in critical and emerging technologies. Strong partnerships are key to sustaining this leadership.

#### **FUSION IGNITION AT THE NATIONAL IGNITION FACILITY**

On December 5, 2022, the National Ignition Facility (NIF) achieved fusion ignition, which had never before been demonstrated in a laboratory setting. Fusion powers the sun and is critically important to the functioning of the U.S. nuclear deterrent, which is why LLNL developed world leadership capabilities in inertial confinement fusion (ICF) to assure the safety and effectiveness of our nuclear weapons stockpile. NIF's 192 laser beams delivered 2.05 megajoules (MJ) of energy to implode a small pellet of fuel and produced 3.15 MJ of fusion energy. This success is a striking example of what national laboratories are able to achieve in decades-long research efforts with strong national support and drawing the expertise of laboratory staff and a broad community of partners.

NIF is a cornerstone of the NNSA's Stockpile Stewardship Program. The capability NIF now offers to conduct fusion experiments, explore fusion science and high-energy-density (HED) physics, and validate HPC simulations of weapons physics strengthens our capability to sustain and modernize the nation's nuclear deterrent without conducting nuclear explosive testing. Demonstration of fusion ignition is also a giant first step forward on the path of using fusion as a carbon-free, abundant source of energy for humankind.

***Innovation and sustained support for long-term national S&T priorities.*** The achievement of fusion ignition was a 60-year-long journey that would not have been possible without innovations and the sustained support of Congress through setbacks, periods of slow progress,

ignition success, and challenges yet to be faced. In 1960, nearly coincidental with the invention of the laser, innovative scientists at Livermore invented the concept of ICF. Computer simulations showed that a symmetric, powerful burst of radiation could implode a miniscule capsule and initiate a small fusion reaction. In the early 1970s, the Atomic Energy Commission approved construction of LLNL's first large multi-beam laser system. ICF was viewed as an ideal, long-term undertaking for a national laboratory, requiring major S&T breakthroughs, enabling exploration of HED conditions to support the weapons program, and offering the potential for fusion power.

The large step to construction of NIF, sixty times more capable than its predecessor, required many innovations and the major commitment of the nation to stop nuclear testing and undertake a science-based stockpile stewardship, including NIF as a key component of the program. Whether NIF would provide enough laser energy to achieve ignition was uncertain. NIF opened for operations in 2009, 12 years after construction began. A series of innovations beginning in 2013 launched significant progress toward the goal and important breakthroughs on many fronts in 2021–2022 led to success.

***National laboratories as critical enablers of U.S. S&T leadership.*** LLNL scientists and engineers designed and managed NIF construction, and the facility is maintained, operated, and continually upgraded by LLNL staff. NIF's design and national award-winning construction project drew on expertise gained in designing, building, and operating earlier laser systems at the Laboratory. An engineering marvel, the gigantic laser system functions with nano-scale precision. NIF incorporated numerous innovative leaps in laser technology that required engineering development in parallel with facility construction. Seven technological "miracles" were required – breakthroughs ranging from precision fabrication of targets to optical switches, deformable mirrors, and glass for high-power lasers. These advances have found application in many endeavors, including adaptive optics for astronomy, pioneering advances in extreme ultraviolet lithography, and high-average-power lasers for scientific discovery.

The nearly 4,000 shots fired at NIF before achieving ignition have provided outstanding support to NNSA's national security mission. As a user facility, NIF experiments have advanced HED science and astrophysics through a Discovery Science program. Laboratory staff and the ICF community have worked together effectively to overcome major hurdles in achieving ignition. Important factors that ultimately led to success include innovations in target design, state-of-the-art diagnostics, simulation modeling aided by artificial intelligence, advancements in target fabrication, and multiple improvements that enabled experiments at higher levels of laser energy and power. These advances accelerate progress in HED science and enhance NIF's vital contributions in its mission areas.

***Strong public-private partnerships.*** One of the most enriching aspects of the pursuit of ignition has been the development of partnerships and collaborations that enabled progress. The ignition success is a testament to the strength of the U.S. research ecosystem, which is founded on world class universities yielding a steady supply of well-trained, innovative talent that brings new ideas and a can-do spirit to the national innovation enterprise. Such impossible accomplishments such as fusion ignition are the result. Thousands of people have contributed to this endeavor, and it took real vision and dedication to succeed. That vision and dedication goes

to the core of what national laboratories do.

Building NIF was an unprecedented scientific and engineering challenge, engaging U.S. industry in large construction contracts and procurements that drove many high-technology companies to advance the state of the art. For example, over a four-year period the Laboratory procured \$550 million of laser hardware to be used in the assembly and installation of over 6,200 precision optics assemblies. Over the last decade, more than 120 diagnostics were designed, developed, and procured. NIF has benefited from decades of experience and ongoing collaborations with national and international partners. A multi-laboratory diagnostics collaboration called the National Diagnostics Working Group was established in 2013 to develop state-of-the-art diagnostics for all the HED science laboratories funded by NNSA.

This year, building on the ignition success, LLNL launched an institutional initiative in Inertial Fusion Energy (IFE). By leveraging decades of investment by NNSA in ICF and exploiting emerging technologies, this initiative seeks to provide IFE leadership on the national and international stage, develop LLNL technical efforts in areas highly synergistic with the Stockpile Stewardship mission, and importantly, work with the community to support the emerging public and private IFE landscape.

#### **NATIONAL LABORATORIES ADDRESS WIDE-RANGING CHALLENGES**

Fusion ignition is a particularly exceptional example of innovative multi-disciplinary research at DOE laboratories making a strong contribution to national security through the innovative advance of S&T. A few other examples—drawing on partnerships in which LLNL participated—illustrate the diverse ways national laboratories make a difference.

***Human Genome Project and ATOM.*** The technology that led to the Human Genome Project—and that has yielded the tools that today allow us to create advanced pharmaceuticals—was developed in the national labs and enabled by public investment sustained over decades. Innovative work at LLNL, Los Alamos, and Lawrence Berkeley national laboratories led DOE to undertake the task of mapping and sequencing the human genome in 1987. DOE noted that the laboratories were particularly well suited for the task because of their demonstrated expertise in managing complex, long-term multidisciplinary tasks. Three years later, the DOE Human Genome Initiative joined with the National Institutes of Health and other laboratories around the world to kick off the Human Genome Project. DOE laboratories mapped three of the 23 chromosomes.

The Laboratory's efforts in bioscience and bioengineering led to the establishment in 2016 of ATOM—Accelerating Therapeutics for Opportunities in Medicine. ATOM is a public-private consortium that was formed under a Consortium Agreement signed by LLNL, GlaxoSmithKline, the National Cancer Institute's Frederick National Laboratory for Cancer Research, and the University of California, San Francisco. The consortium has grown to include Oak Ridge, Argonne, and Brookhaven national laboratories. ATOM is developing a pre-clinical drug design and optimization platform that leads with computation to help shorten the drug discovery timeline.

**Advanced Supercomputing.** Sustained public investment, driven by national security needs, powered a multi-decade effort that led the U.S. to a place of global leadership in HPC. Supported by DOE's 7-year-long Exascale Project, Oak Ridge National Laboratory is currently home to Frontier, the world's fastest supercomputer, capable of 1.85 exaflops (quintillion operations per second) peak speed. This year, LLNL will take delivery of El Capitan, with peak performance greater than 2 exaflops in the next step of NNSA's Advanced Computing and Simulation (ASC) program. NNSA's investment in HPC has led to more than a million-fold improvement in computing speed since the start of the Stockpile Stewardship Program in 1992. But our nation's HPC leadership is not guaranteed; "We would do well not to give it up" because computing has changed—and is changing—everything we do. Modeling and simulation that can be performed with exascale HPC has pushed science forward in amazing ways. And now, artificial intelligence and machine learning can ingest enormous amounts of data and dramatically enhance our ability to make advances in fields ranging from stockpile stewardship to bioscience.

**EUVL.** In the late 1990s, LLNL, Sandia National Laboratories, and Lawrence Berkeley National Laboratory—the Virtual National Laboratory—developed extreme ultraviolet lithography (EUVL), a breakthrough in chip printing technology that allowed manufacturers to print significantly smaller circuit lines and pack in more processing power. This technology was rooted in LLNL's work on x-ray lasers, specifically the diagnostics that worked in this spectral range. The work was funded by Intel, AMD, and Motorola in a three-year Cooperative Research and Development Agreement (CRADA). It took almost two decades to incorporate EUVL into semiconductor manufacturing and produce chips that went into commercial smartphones. In 2016, LLNL partnered with ASML Holding NV to advance EUV light sources toward the manufacturing of next-generation semiconductors. This project leveraged LLNL's expertise in lasers and plasma physics and the ability to perform complex, large-scale modeling and simulation using HPC. The partnership helped ASML produce systems that enabled 7-nm mobile phone chips in 2019 and 5-nm chips in 2020. In 2020, Apple's iPhone 12s became the first mobile phones on the market powered by 5-nanometer (nm) microprocessors, which are manufactured using a transistor-packing EUVL process that can be traced back to the EUV technology by the national laboratories. "Everyone's iPhone has a little bit of LLNL inside."

These accomplishments exemplify how national laboratories' S&T is at the critical core of U.S. competitiveness and drives global leadership. The network of laboratories could not play this role without a world class workforce. Our people are the key to everything. The national laboratories need to be able to continue to hire the best and brightest; people are the indispensable ingredient. In a competitive world, because we are leaders, we will have adversaries that try to steal from us. To maintain our leadership, we must be vigilant, but we cannot shut down collaborations and engagement with the rest of the world. Capabilities matter too: to draw scientists, engineers, and technicians into the national lab system, we must maintain leading edge experimental capabilities, particularly the user facilities that provide high performance computing, fusion experimental platforms, x-ray light sources and other capabilities

to drive American science and innovation

#### **INVESTING IN NATIONAL LABORATORIES TO SUSTAIN LEADERSHIP**

The national security community has played a crucial role in many of the advances I've described. In both computing and HED science, we are reaping enormous benefits outside of national defense applications, but only because of investments driven by national security priorities.

Public private partnerships have played a significant part in most of the laboratories' S&T successes. But the government's role is crucial: without sustained public investment in student and workforce development, cutting edge research facilities including advanced research user facilities at national labs, and the innovative research enterprise that is the envy of the world, the U.S. would not be a leader in such essential areas as HPC, nor would we have been the first to achieve controlled fusion ignition in a laboratory.

Only with reliable, sustained federal funding can the labs continue to hire, train and keep the people we rely on for national security and innovation leadership. And only with consistent public support can we maintain the world-class facilities that both help us attract our workforce and enable the cutting-edge science that keeps the U.S. in a position of global leadership.



SCIENCE &amp; TECHNOLOGY ON A MISSION

## Kimberly S. Budil, Ph.D.

Director

Lawrence Livermore National Laboratory

Director Kim Budil leads a workforce of nearly 8,000 employees and manages an annual operating budget of approximately \$2.7 billion. As Laboratory Director she shares the responsibility, along with the directors of Los Alamos and Sandia National Laboratories, of providing the U.S. President, through the Secretaries of Energy and Defense, an annual assessment of the safety, security, and effectiveness of the U.S. nuclear weapons stockpile, and whether confidence in the stockpile can be maintained without a nuclear test. She is strongly committed to LLNL's tradition of scientific and technical excellence in service to the Nation.

Budil has more than three decades of experience across LLNL's scientific and national security programs. She most recently served as the Principal Associate Director for Weapons and Complex Integration, responsible for the programs that ensure the safety, security, and effectiveness of the Nation's nuclear deterrent as well as advancing the supporting science, technology, and engineering capabilities. Prior to this, she served as the Vice President for National Laboratories at the University of California Office of the President, where she led the University's oversight and governance of LLNL, Lawrence Berkeley National Laboratory, and Los Alamos National Laboratory. She served twice on special assignment in Washington, DC, including as a Senior Adviser to the Under Secretary for Science at the Department of Energy (DOE). She has served on many boards and committees and has been an active champion for diversity, equity, and inclusion at the national labs and beyond. She has M.S. and Ph.D. degrees in applied science/engineering from University of California, Davis where she was the recipient of a Hertz Foundation Fellowship, and a B.S. in physics from the University of Illinois at Chicago. Dr. Budil completed a certificate in national security affairs from the Bush School of Government and Public Policy at Texas A&M University. In 2019 she was named a Fellow of the American Physical Society.



Kimberly S. Budil

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Chairman LUCAS. Absolutely, Doctor.  
And we now turn to Mr. Kitchen for 5 minutes.

**TESTIMONY OF MR. KLON KITCHEN,  
SENIOR FELLOW, AMERICAN ENTERPRISE INSTITUTE**

Mr. KITCHEN. Chairman Lucas, Congresswoman Bonamici, thank you for the opportunity to testify before the Committee.

The United States Science and Technology enterprise is strong and continues to be the envy of the world. American companies are pioneering and deploying innovations and technology that can expand human thriving, broaden economic prosperity, and ensure the national security for generations to come. But to do these things, we must deliberately address three key challenges to the American Science and Technology Enterprise.

First, we must confront Chinese technological theft and aggression. Beijing, like Washington, understands that emerging technologies like artificial intelligence, advanced robotics, and quantum science will decisively shape tomorrow's societies, economies, and battlefields, and that these innovations are overwhelmingly being developed in the private sector. But unlike the United States, the People's Republic of China is not committed to free and fair competition in global innovation. Instead, the Chinese Communist Party is co-opting its innovation industry and using it as an extension of the State for traditional and economic espionage that FBI (Federal Bureau of Investigation) Director Christopher Wray has said surpasses every other nation combined and represents one of the largest transfers of wealth in human history. Whether through social media companies like TikTok, drone companies like DJI and Autel, or smart device companies like Tuya, the U.S. science and innovation enterprise, which spans the public and private sectors, is hemorrhaging data and intellectual property and will be left emaciated if these losses are not stopped.

Second, we must help our allies understand that a strategy of regulate first and ask questions later will hurt, not help, all of us and risk ceding the advantage to Beijing. Other governments, particularly those in the European Union, are enacting laws that deliberately target American innovation companies that preference their domestic champions. And that's threatened to splinter the internet itself into a series of mini-nets, each running on incompatible infrastructure and governed by contradictory rules. Even more, the economic scarcity that would inevitably flow from such a splintering would leave these partners more susceptible to the siren song of cheap cloud services and other offerings from China, which are heavily subsidized by the CCP, as previously discussed, for the express purpose of stealing a country's data and wealth. If this happens, many of our friends will have lost their sovereignty and security in their bids to keep them.

Finally, domestic debates about technology and innovation must be constrained by facts and geopolitical realities. Every institution and industry must be held accountable to U.S. law, and national security concerns cannot be wantonly employed as a get-out-of-jail-free card. Neither, however, should perceived but unsubstantiated political grievances be used to justify counterproductive or even un-

constitutional actions against the very science and technology enterprise at the heart of our individual and national prosperity.

Pushing the frontiers of science and pioneering game-changing technologies is expensive. The resources and talent to do these things are highly valuable and desperately scarce. It is no coincidence that the companies that have found ways to attract billions of customers and the profits that come with them are the same companies at the center of our science and technology enterprise. They innovate at scale because they operate at scale. Instead of rallying against these companies because of their size, we instead should be thankful that our free market economy has produced an alignment of interests, where private sector actors can generate wealth and jobs, while also developing the capabilities that will provide for the common defense. This uniquely American advantage may well be decisive in an era of escalating geopolitical competition. It would be reckless to give it away.

There is much more that I could say on these matters, but I'll end my remarks there. Thank you again for this opportunity, and I look forward to your questions.

[The prepared statement of Mr. Kitchen follows:]



Statement before the House Committee on Science, Space, and Technology  
*On The United States, China, and the Fight for Global Leadership: Building a U.S.  
National Science and Technology Strategy.*

## The New Superpowers

How and Why the Tech Industry is Shaping the International  
System

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### Opening Statement

Good morning. Chairman Lucas and Ranking Member Lofgren, thank you for the opportunity to testify before this committee.

The United States' science and technology enterprise is strong and continues to be the envy of the world. American companies are pioneering and deploying innovations and technology that can expand human thriving, broaden economic prosperity, and ensure our national security for generations to come.

But to do these things, we must deliberately address three key challenges to the American science and technology enterprise.

First, we must confront Chinese technological theft and aggression. Beijing, like Washington, understands that emerging technologies like artificial intelligence (AI), robotics, and quantum science will decisively shape tomorrow's societies, economies, and battlefields and that these innovations are overwhelmingly being developed in the private sector. But unlike the United States, the People's Republic of China is not committed to free and fair competition in global innovation. Instead, the Chinese Communist Party (CCP) is coopting its innovation industry and using it as an extension of the state for traditional and economic espionage that FBI Director Christopher Wray says surpasses "every other nation combined" and "represents one of the largest transfers of wealth in human history."

Whether through social media companies like TikTok, drone companies like DJI and Autel, or smart device companies like Tuya, the U.S. science and innovation enterprise—which spans the public and private sectors—is hemorrhaging data and intellectual property and could soon bleed out if these losses are not stopped.

Second, we must help allies understand that a strategy of "regulate first and ask questions later," will hurt—not help—all of us and risks ceding the advantage to Beijing. Other governments, particularly those in the European Union (EU), are enacting laws that deliberately target American innovation companies, preference domestic champions, and threaten to splinter the internet itself into a series of "mininets," each running on incompatible infrastructure and governed by contradictory rules. Even more, the economic scarcity that would inevitably follow such a splintering would leave these partners more susceptible to the siren song of cheap cloud services and other offerings from China, which are heavily subsidized by CCP, as previously discussed, for the express purpose of stealing a country's data and wealth. If this happens, many of our friends will have lost their sovereignty and security in their bid to keep them.

Finally, domestic debates about technology and innovation must be constrained by facts and by geopolitical realities. Every institution and industry must be held accountable to U.S. law and national security concerns cannot be wantonly employed as a "get out of jail free" card. Neither, however, should perceived—but unsubstantiated—political grievances be used to justify counterproductive, or even unconstitutional, actions against the very science and technology enterprise at the heart of our individual and national prosperity.

Pushing the frontiers of science and pioneering game-changing technologies is expensive.

The resources and talent to do these things are highly valuable and desperately scarce. It is no coincidence, then, that the companies that have found ways to attract billions of customers — and the profits that come with them — are the ones at the center of our science and technology enterprise. They can innovate at scale *because* they operate at scale.

Instead of railing against these companies because of their size, we instead should be thankful that our free-market economy has produced an alignment of interests where private-sector actors can generate wealth and jobs while also developing capabilities that will provide for the common defense. This uniquely American advantage may well be decisive in an era of escalating geopolitical competition. It would be reckless to give it away.

While there is much more that I could say, I'll end my remarks there.

**Thank you again for this opportunity and I look forward to your questions.**

### **Background**

Technology is always a key variable in geostrategic change. The sailboat, gun powder, the steam engine, the internal-combustion engine, nuclear power, modern communications and information technology — these and other innovations revolutionized their respective eras and changed the fortunes of nations. So it is today. The so-called “fourth industrial revolution” is shaping and re-shaping the contours of the emerging global order. Even more, the companies at the heart of this revolution are fast becoming powerful geopolitical stakeholders that often challenge the authority, sovereignty, and the capacity of governments. Three trends have special prominence in driving this change.

First, a growing number of technology companies have global interests and influence. In 2016, global technology spending exceeded \$6.3 trillion, making it the “third largest economic ‘force’ in GDP terms, surpassed only by the United States ... and China.”<sup>[i]</sup> One report predicts that by 2023, more than 50 percent of world-wide GDP will be driven by services and products from digitally transformed industries.<sup>[ii]</sup> In 2018 alone, Apple brought in \$265.6 billion in net revenue; Amazon earned \$232.9 billion; Google’s parent company, Alphabet, earned \$136.8 billion; Microsoft earned \$110.4 billion; and, Facebook earned \$55.8 billion.<sup>[iii]</sup> These five companies alone constitute more than \$801.5 billion in annual revenue (not even net worth), which is roughly the size of Saudi Arabia’s nominal GDP in 2018.<sup>[iv]</sup> But this is about more than money, it is about the influence these resources command.

There is perhaps no industry more globalized than the technology industry. All of the companies mentioned above, for example, compete in every major market around the world, conduct research and design in multiple countries, and employ a globally derived and deployed talent pool to develop and to build their products and services. This, then, translates into an expanding global presence and a growing lists of corporate interests that

transcend national boundaries and that directly influence, and are influenced by, geopolitical events. Put simply: the world's largest technology companies are amassing a level of wealth, influence, international presence, and transnational interests that was previously only enjoyed by states. But these companies are more than just players in the game of global politics, they are often the arena itself.

The second trend driving the rise of technology companies in geopolitics is the expanding presence and role of digital and social media. While propaganda and so-called "active measures" have long been a feature of geopolitical engagement, Russia's interference in the U.S.'s 2016 presidential elections – and in a number of other foreign elections since – places in stark relief the reality that modern communications technology and social media platforms are combining to produce an unparalleled tool for legitimate political discussion and action, but that these tools also extend to bad actors. Even more, the burden for preventing, identifying, and confronting this interference largely falls to the companies themselves. Political leaders may punish companies for not preventing misinformation on social media, but governments can do little by themselves to stop it.

Governments all over the world are asking, begging, and even threatening these companies in an effort to get their collective hands around the challenge; but, there is very little that political leaders can unilaterally do to dramatically improve the situation. The difficult reality that many are struggling to adapt to is that private sector technology actors have built a capability for wide-scale political influence that largely falls outside of the control of political leaders. And this asymmetry is indicative of an even broader reality.

The third and final critical trend is that technology companies are a, if not the, center of gravity in the development of critical national security capabilities and methodologies. Governments have always sought to observe, to understand, to predict, and to shape human behavior and events. These are essential aspects of what is historically called, "intelligence." Technology companies call this "market research," "product development," or "service provisioning." Regardless of the euphemism used, the plain truth is that the state has lost its monopoly on intelligence and private sector actors know more about individuals and societies than any government spy agency – perhaps even more than all government spy agencies. This is why the short-hand "surveillance capitalism" is sometimes used to describe the business model of the world's tech titans, and the term "surveillance" is appropriate when considering their ability to collect and to understand data.

It is estimated that more than 5 billion people (roughly 65% of the global population) have mobile devices and that half of these devices are smartphones.<sup>[v]</sup> Nearly all of these people (approximately 4.17 billion) can be considered "mobile internet users" and this number is expected to nearly-double by 2021.<sup>[vi]</sup> As more users are brought online, so is their data and this data provides powerful insights. As the Electronic Frontier Foundation (EFF) observes in its report, *Behind the One-Way Mirror: A Deep Dive Into the Technology of Corporate Surveillance*:

Every smartphone is a pocket-sized GPS tracker, constantly broadcasting its location to

parties unknown via the Internet. Internet-connected devices with cameras and microphones carry the inherent risk of conversion into silent wiretaps ... But these better known surveillance channels are not the most common, or even necessarily the most threatening ... The most prevalent threat to our privacy is the slow, steady, relentless accumulation of relatively mundane data points about how we live our lives. This includes things like browsing history, app usage, purchases, and geolocation data. These humble parts can be combined into an exceptionally revealing whole. Trackers assemble data about our clicks, impressions, taps, and movement into sprawling *behavioral profiles*, which can reveal political affiliation, religious belief, sexual identity and activity, race and ethnicity, education level, income bracket, purchasing habits, and physical and mental health.<sup>[vii]</sup>

While not all observers share EFF's alarm, their observation is undeniable – digital data collection grants these companies unparalleled insight into human behavior which, in turn, gives them unparalleled capabilities to predict and to shape this behavior. For example, both Google and Facebook have filed patents that use historical location data and offline behaviors to accurately predict where users will be in the future, even years in the future, so that the companies can pro-actively serve up contextually-relevant ads and services.<sup>[viii]</sup> While not inherently nefarious, this is a powerful capability. A capability that demonstrates not just the ability to generate and to collect data, but also to understand and to leverage this data. Something accurately described as “intelligence analysis.”

Simply having data is not valuable. Having the ability to interrogate and to exploit that data is crucial for realizing its value, and private companies are the ones leading the development of analytic tools and methodologies for realizing this value. Perhaps most importantly, by employing artificial intelligence (AI).

AI can be understood as the use of machines to accomplish tasks that normally require human intelligence, such as decision-making, image recognition, and language translation. Around 2012, the AI sub-discipline of “machine learning” took a big leap forward when advancing computer science, specialized hardware, and large volumes of digitized data combined to enable a new type of programming that greatly reduces the burden of training AI algorithms – sparking a renaissance of AI applications that already touch many American lives far beyond their smartphones. Hospitals use them to diagnose diseases and to predict inpatient mortality rates. Insurance and mortgage companies use them to assess risk. Law enforcement use them for “predictive policing” while our judicial system is testing them in sentencing formulas. These algorithms even conduct as much as 80% of daily trades on the U.S. stock exchange.<sup>[ix]</sup> The application potential of AI is far-reaching, including into the realm of defense and national security.

It is an overstatement to say that all governments are trailing woefully behind the private sector in the development of AI; but, even the most advanced governments – like those in the United States and in China – are hobbled by the inherent slowness of bureaucracy and by an acute lack of technical competence. Governments can partner with academic and commercial partners to conduct and to support research; but, they seemingly cannot attract the human talent necessary to implement and leverage this research at the scale or speed

necessary for keeping up with national security requirements. And this is equally true regarding other technologies beyond AI. The inescapable fact is that the growing data and capability gaps between the private sector and governments leaves national security leaders increasingly dependent on technology companies to conduct core national security missions. This is why former Chairman of the U.S.'s Joint Chiefs of Staff, GEN(ret) Joe Dunford, observed, "Our ability to leverage industry here in the United States; our ability to maintain a technological edge over any potential adversary, is going to very much depend on the partnership between industry and the Department of Defense."<sup>[x]</sup> (Garamone, 2019)

Do not miss the import of this statement: the former senior military advisor to the President of the United States is saying that the nation's ability to secure itself "depends" on partnering with the private sector in some new and sustained way. This same sentiment is shared by political leaders around the world and is being expressed in three general government reactions.

#### Three Government Responses to Tech's Growing Geopolitical Influence

The migration of geopolitical influence into the private sector is provoking a range of government responses. These responses are rooted in a number of variables, including a nation's specific political form, its relative economic strength, and its broader global ambitions. Specifically, the responses from the United States, China, and Europe are helpful for understanding the evolving relationship between technology and governance.

##### *The United States: "Engage and Invest"*

The U.S. response can be summarized as "engage and invest." American policymakers are consistently being told by national security leaders that the nation's "overmatch" capability – the U.S.'s relative military superiority over its international competitors – is eroding and that the speed of this erosion is increasing. Additionally, in light of the point made above about private companies being a significant source of modern national security capabilities, these policymakers are being told that this capability deficit is not simply a matter of funding. The U.S. cannot write a check big enough to erase our losses and to ensure our long-term superiority. We are dependent, as Dunford said, on private sector actors. Unfortunately, "big tech" responses to government overtures have been uneven.

Companies like Microsoft and Amazon, both of whom are competing over a \$10 billion contract to provide cloud services for the Pentagon, have clearly signaled their intent to work with the Federal government. Amazon CEO Jeff Bezos, for example, has called on other tech companies to work with the U.S. government, calling the nation "the good guys." "I know it's complicated, but do you want a strong national defense or don't you? I think you do," says Bezos.<sup>[xi]</sup> Similarly, Microsoft CEO Satya Nadella responded to critics of his company's government work, saying, "...[W]e're not going to withhold technology from institutions that we have elected in democracies to protect the freedoms we enjoy."<sup>[xii]</sup> Other tech leaders, however, have gone a different way – most notably, Google.

In 2018, Google ended its participation in the Pentagon's multifaceted AI research effort,

Project Maven. The decision followed the publication of a protest petition that was signed by more than 4,000 Google employees and after 12 of the company's engineers resigned. The petitioners maintained that, "...Google should not be in the business of war" and that the company's participation in Project Maven violated their informal oath to not to be "evil." Whether motivated by practical or ideological reasons, Google leaders acquiesced to the complaint by withdrawing and by issuing a set of AI principles that include prohibitions against using AI for "weapons," "surveillance," or threatening "human rights." The company has not issued a statement reconciling these AI principles with its new AI research center in China, where more than one million religious and political minorities are being surveilled, imprisoned, brainwashed, and murdered.

Obviously, there are a large number of small and medium technology companies who are more than happy to work with the federal government; however, generally, the most interesting work on some of the most consequential technologies is being done by the large technology companies who must navigate complex fiduciary and consumer requirements and demands. Even so, U.S. political and national security leaders continue to engage with technology leaders and are hopeful that a more robust and systemic collaboration will be established. But hope is not the U.S.'s only strategy. The government is also making large investments in these technologies.

For example, the President's 2020 budget prioritizes AI as one of four "Industries of the Future," and sets aside \$1 billion for non-defense-related AI. While much of the national security spending on AI is classified, the Defense Advanced Research Projects Agency's (DARPA) "AI Next" campaign will invest more than \$2 billion in the technology over multiple years. The administration has also issued an executive order establishing the "American AI Initiative" and it has published an "AI R&D Strategic Plan." The latter of these efforts identifies key AI priorities, including (1) long-term investments (2) human-AI collaboration (3) ethical, legal, and social implications of AI (4) AI safety and security (5) public datasets and training areas (6) AI standards and benchmarks (7) the AI workforce and (8) expanding private-public partnerships.

These and other government efforts on technologies like quantum science, bio-technologies, and advanced synthetic materials demonstrate that Washington understands the importance and long-term necessity of these capabilities; but, the nation's ability to fully leverage the capacity of the private sector towards these ends remains unproven. Doing so will be difficult and it will be made even more difficult by the U.S.'s historical aversion to formalized industrial policy and by a general "hands-off" approach when it comes to government interference with private sector economic activity. The U.S. derives many benefits from these approaches; but, they do come at a cost.

The Chinese have opted for another approach.

#### *China: "Fuse and Use"*

China's response to the growing role of technology in geopolitical affairs is to "fuse and use." Before unpacking this further, two observations will be helpful.

First, China is like every other nation in the history of the world, in that it seeks to amass and to wield geopolitical influence in an effort to secure and to advance its national interests. This is rational and the only coherent way for nations to operate within the global system. Further, a series of official Chinese strategies makes it clear that the Chinese Communist Party (CCP) believes their nation must lead in at least 10 technology-related industries<sup>[1]</sup> if it wants to effectively build and employ this influence in the emerging international system. Again, this assessment is sound and this approach is coherent.

A second observation concerns why China has made these conclusions – specifically as a response to U.S. technical and military superiority. After observing the U.S. advanced warfighting capabilities during Operation Desert Storm, then Chinese President Jiang Zemin directed his military leaders to be ready to fight “local wars under high technology conditions.”<sup>[xiii]</sup> This, then, set off a national effort to reassert China’s technological leadership that has since been adopted and expanded by President Xi Jinping – which brings us to “fuse and use.”

In their excellent report, *Beating the Americans at Their Own Game: An Offset Strategy with Chinese Characteristics*, former Deputy Secretary of Defense Robert O. Work and co-author Greg Grant, describe the Chinese strategy for achieve technological dominance as having three distinct phases. Phase One begins with Beijing competing with Washington from a position of technological inferiority and focuses on closing key capability gaps. Phase Two begins when China establishes rough technological parity, allowing the country to deter U.S. intervention within China’s strategic area of influence (i.e., East Asia). Finally, Phase Three constitutes the desired end state where China has surpassed American technological leadership and is able to confidently project its influence as far abroad as is necessary.<sup>[xiv]</sup> In all three phases, Chinese civil society and private sector entities plays a key role.

Historically, China has never made a clear distinction between its public and private sectors. Instead, for at least the last 60 years, China has employed what scholar Branko Milanovic calls “political capitalism,” which has three defining features:

First, the state is run by a technocratic bureaucracy, which owes its legitimacy to economic growth. Second, although the state has laws, these are applied arbitrarily, much to the benefit of elites, who can decline to apply the law when it is inconvenient or apply it with full force to punish opponents. This arbitrariness of the rule of law in these societies feeds into political capitalism’s third defining feature: the necessary autonomy of the state. In order for the state to act decisively, it needs to be free from legal constraints. The tension between the first and second principles – between technocratic bureaucracy and the loose application of the law – produces corruption, which is an integral part of the way the political capitalist system is set up, not an anomaly.<sup>[xv]</sup>

It is within this system that Chinese (and foreign) technology researchers and companies operate, an environment where the state is unbound by law and totally free to direct, subsidize, and coerce private sector support for official government priorities and policies.

In the case of national security related policies, this is known as “military-civil fusion.”

In 2018, You Zheng, Vice President of China’s Tsinghua University (often called “China’s MIT”), wrote an article, outlining the university’s commitment to supporting the state – specifically on the development and use of AI:

In accordance with central requirements, Tsinghua University will closely integrate the national strategy of military-civilian integration and the AI superpower strategy. Tsinghua University was entrusted by the CMC [*Central Military Commission*] Science and Technology Commission to take responsibility to construct the High-End Laboratory for Military Intelligence (军事智能高端实验室). With regard to basic theories and core technologies, military intelligence and general AI possess commonalities. Therefore, Tsinghua University regards the construction of the High-End Laboratory for Military Intelligence as the core starting point for serving the AI superpower strategy.... Therefore, Tsinghua University insists on basic research as a support in applied technology research in AI talent training and scientific research innovation, with military requirements as a guide, promoting the development of basic AI research.[\[xvi\]](#)

Put simply: China’s leading engineering and computer science university, “in accordance with central requirements”, makes no distinction between basic AI research and its application to state and military requirements. This fusion extends beyond the academy and to “private” companies as well, with Beijing even using these companies as extensions of the state. Huawei is a prime example of this “fuse and use” strategy.

In 1987, a former military technologist and officer in the Chinese People’s Liberation Army (PLA), Ren Zhengfei, started the Huawei telecommunications company. Since then, the company has become one of the world’s leading providers of telecommunications hardware, software, and services – often with direct and indirect support from the Chinese government. In response to this support, intelligence services around the world assess the company routinely steals intellectual property from other companies and nations – feeding these innovations into its own research and design efforts as well as those of the government. Its deployed infrastructure is also suspected of operating as a type of backbone network for much of Beijing’s technical espionage around the world. For example, in 2012 the Chinese government “gifted” a new headquarters building to the African Union in Addis Ababa, Ethiopia. Huawei and another Chinese company, ZTE, were tasked with providing the head quarter’s computer and communications networks. After five years of operating, it was discovered that all of the Union’s confidential data and communications was copied and forwarded to Chinese servers every single night. This is just one of many examples of how just this one technology company operates on behalf of the Chinese government. There are many, many more.

“Fuse and use” is further supported by a growing list of cybersecurity and national security laws in China that require all companies, even wholly foreign owned companies, to arrange and manage their computer networks so that the Chinese government has access to every bit and byte of data that is stored on, transits over, or in any other way touches Chinese

information infrastructure. It will even include data on U.S. persons collected by Chinese companies like TikTok, WeChat, and Alibaba. Any data that is not automatically collected and turned over to the government must be provided upon request, according to *The National Security Law of the People's Republic of China* that was enacted in 2015 and updated in 2017.

All of this is emblematic of the nation's response to the growing import of technology within geopolitical affairs and its implications extend far beyond China's borders.

*Europe: "Strangle and Surrender"*

In the cases of the U.S. and China, where both countries have robust domestic technology industries, the governments seek to leverage these companies in support of national security – the former through voluntary cooperation based on shared interests and the latter through incentivized and coerced partnership based on the power of the state. In Europe, where the technology industrial base is comparatively weak, governments appear to be content with strangling technological innovation with regulations while simultaneously surrendering their national and cyber security to foreign actors – though, there are some reasons for hope.

The most sweeping action taken in Europe in dealing with technology companies has been the European Union's (EU) passage of the General Data Protection Regulation (GDPR). The law is a hodgepodge of regulations spelled out in 11 chapters, covering "general provisions", "principles", "rights of data subject", duties of data controllers or processors, transfers of personal data to third countries, "supervisory authorities", "remedies", "liabilities and penalties", and other miscellaneous provisions. GDPR is so bloated and cumbersome that Google, one of the largest, most profitable companies in the history of mankind, says it has spent "hundreds of years of human time" (Rodriguez, 2018) coming into compliance with GDPR. [\[xvii\]](#) Now imagine being a would-be disruptor in someone's garage and having to navigate these requirements – you would have no chance. GDPR and Europe's general regulatory heavy-handedness is precisely why these nations struggle to field meaningful technological innovation are likely to do so going forward. Even worse than strangling their own technological industrial base, is Europe's seemingly naïve integration of Chinese technology into their critical networks and markets.

Despite clear warnings from the United States and often from their own intelligence services, Germany, France, Italy, and others are actively considering allowing Huawei to supply, or at least have a significant presence in, their burgeoning fifth-generation (5G) wireless networks. This is despite clear signals that doing this could endanger U.S. willingness to share critical intelligence with these countries. When pressed on these decisions, European political leaders often opine about the lack of alternative providers and the significant costs savings that can be realized by going with Chinese companies (Huawei's bid in Italy, for example, is as much as 2/3 cheaper than all of the other bids). What these leaders seem to be unwilling to ask is, how and why are the Chinese bids so much cheaper?

As discussed previously, the Chinese government will subsidize their domestic companies to

allow them to underbid competitors and to gain larger market share around the world. This allows the companies greater access to new markets and expands Beijing's political and technical influence as well. If profit is not the motive for Chinese companies bidding for European technology contracts, then political leaders ought to ask themselves what is the real motivation?

It has become popular recently, for EU leaders to say they will mitigate the cybersecurity threats associated with Huawei and other Chinese companies by adopting stringent security requirements and by keeping these companies out of critical portions of their networks. This is foolishness. First, it misunderstands how next-generation wireless networks work. Legacy distinctions between critical and non-crucial nodes of the network are largely being erased and it is not reasonable to believe threats can be contained within non-sensitive areas. It is also not safe or sane to make an existential bet that you will always be able to prevent one of the world's top cyber threats from critically compromising your networks. Second, even if they could mitigate software vulnerabilities and so-called "backdoors," they will have done nothing about Beijing's domestic laws that grant them unfettered digital access to any and all traffic found on the networks of Chinese companies – wherever they are operating. As frightening as these decisions and justifications are, the reality behind them is even more concerning.

Decades of government mismanagement, spending, and general neglect are leaving a large number of European capitals unable and unwilling to make the hard choice of foregoing near-term economic benefit in return for long-term security. As these governments continue to default on their myriad promises of cradle-to-grave entitlements, they will also bleed political legitimacy in the eyes of their constituents and, therefore, become more desperate to provide economic "wins" and critical services – even if it means subjecting themselves to Chinese aggression and coercion. The truth of this is already demonstrated in the fact that 23 European countries have signed agreements under China's predatory "belt and road initiative," 19 of whom are in the EU and one of whom (Italy) is in the G7.

To summarize: Without a strong technological industrial base, and in the face of mounting governance failures, many European countries appear to be making catastrophic security decisions in an effort to placate public dissatisfaction and to keep up with the technological advancements emanating from the United States and China.

#### Two Necessary Adjustments

All of the above leads to two necessary adjustments.

First, the government must accept the reality that it is *a* national security stakeholder and not *the* stakeholder. Many of the world's leading technology companies have global interests and influence on par with many nations -- they have a legitimate place at the geopolitical table.

For example, when it comes to encryption, some government officials dismiss tech companies as standing in the way of national security. This is a myopic caricature of reality.

Encryption is critical to securing private communications, financial systems, intellectual property and other trade secrets. A private company's commitment to securing this data should not make them the enemy -- it makes them an ally. Efforts to secure themselves and their customers against hostile online actors is as essential for our national security as is anything done by the federal government.

To be clear, the case for special access to encrypted materials can be one with noble objectives and intentions; but, technology has changed to make such access detrimental to cybersecurity and data integrity, with no guarantee of success. Policymakers and national security leaders should recognize this and be persistent in trying to find collaborative approaches with industry — recognizing that patience will be required.

Proactively, Washington can best demonstrate its intent to be a true partner with the tech industry in the way it shares information and purchases technology.

On the information sharing side, for too long, the U.S. government has treated information exchange with industry as a one-way street -- demanding "real-time" information sharing from private companies on cybersecurity and other threats while being painfully slow in sharing with industry its own insights about malicious actors, their intentions and their capabilities.

There are early signs this might be changing. The NSA's release of its Ghidra tool is a good example of the government proactively treating industry as a partner. This software reverse engineering framework was developed by Fort Mead for its national security mission but its release to the public allows private sector security personnel to better defend themselves as well.

We've also seen some promising signs out of Cyber Command. It has taken to publishing adversaries' malware samples to public repositories visible to private sector cybersecurity professionals.

As for purchasing and procurement, the government's rigid and outdated acquisition bureaucracy makes it difficult for new technology companies to help Washington, because they need to spend precious resources on engineers and coders rather than hordes of contract specialists and lawyers.

Organizations like the Pentagon's Defense Innovation Unit and the CIA's In-Q-Tel are good at technology scouting and at strategic investment. But we still struggle to transition these technologies from niche experimental programs into stable, long-term solutions.

To put it bluntly, there's plenty of capital in innovation, but these companies do not need government "investment," they need government contracts.

But none of these very real frustrations with the government excuses firms from the responsibilities that come with their growing global influence.

It is precisely because they are amassing this power and influence, and because they are enabled to do so only under the military, legal, and economic protections of the U.S.

government, that these companies must also change.

Specifically, American technology companies must acknowledge their growing national security responsibilities. They must also accept the fact that great power competition is returning and that this return requires them to choose sides.

While the Chinese market may be lucrative, it is also a moral minefield and ultimately a dead end for Western companies.

American companies' submission to Beijing's predatory demands on intellectual property, proprietary information, trade secrets, data and other assets weakens American economic competitiveness, individual and national cybersecurity, and broader national security to the degree that this capitulation enables China's technological ascendancy over the U.S. This participation also gives cover to Beijing's rampant political oppression and human rights violations.

The business risk is extreme, too. Just consider the experience of Microsoft: some 90 percent of Chinese firms use the company's operating system, but only 1 percent actually pay for it. This, according to former Microsoft CEO Steve Ballmer<sup>[xviii]</sup>, costs the company more than \$10 billion in profits. But, thus far, such losses have been accepted as the cost of doing business in what, until recently, was the world's fastest growing market.

But companies that chase short-term profits in the Chinese market over long-term stability are in for a rude shock.

Ultimately, western technology companies and the US government must recognize that the long-term interests of both are better served through national security partnerships. They should do this out of patriotism, out of economic interest, and because these partnerships enable the expansion of truly free markets and human thriving around the world.

#### Concluding Thoughts for Conservatives

The growing influence of technology companies within the international order provokes a complex calculus where values, interests, and objectives must constantly be balanced. It is especially important that Conservatives and others on the political right think deeply about these issues and that they recognize four important factors.

First, technology companies and their capabilities are a key center of gravity in a global contest between liberal democratic society and technologically-enabled authoritarianism. The U.S. and China are both leveraging these companies in the pursuit of broader ends and, despite how powerful these companies are becoming, they are still subject to the will and power of states. If the Chinese model of "fuse and use" is not arrested and pushed back, it will become the chief export along Beijing's belt and road initiative. A number of autocratic leaders are already working with the Chinese government and Chinese companies to build their own version of Sino surveillance state. How the U.S. engages and leverages its own technological industrial base will decisively influence its ability to confront this authoritarian expansion.

Second, the U.S. government must expand its organic capabilities for technological research and design while also dramatically improving its ability to discover and to integrate privately derived innovations before our strategic competitors. Conservatives have always understood that a strong, comprehensive national security enterprise is essential for peace and prosperity. Advocating for these policies was easier and more straight-forward when it largely only meant more money for personnel, bombs, and airplanes. But now that commercial technologies like AI and quantum computing are likely to be decisive, Conservatives must grow comfortable with government-driven exploratory research and adopt a higher risk tolerance for these programs. Relatedly, because so much private sector research is conducted and published publicly, the U.S. government needs to find ways of identifying and acquiring the most important research before our strategic competitors do. Or, at the very least, we need to lessen the friction of transitioning these general research efforts into specific programs of record and acquisition.

Third, the deep integration of the U.S.'s chief rival, China, into its economy and Beijing's policy of "military-civil fusion" challenges many of Conservatism's political orthodoxies -- particularly a certain strain of free market fundamentalism. For many in the conservative movement, the idea of a U.S. industrial policy is considered heresy and is an unthinkable political option. While the concerns associated with such a policy are legitimate, they do not lessen the reality that sectors of America's technological industrial base are critical to national security and that many of these same sectors are equally important to the nation's international trade. The distorting economic impacts of China's coercive economics must be accounted for and we cannot allow the natural "efficiencies" of markets to produce unacceptable national security outcomes.

A growing realization of this reality is demonstrated in the U.S.'s recent responses to the development of 5G and the Chinese owned social media application, TikTok. In both cases, because of legitimate national security concerns, the government has intervened and constrained a Chinese company from "freely" competing. The justifications for these actions extend to a host of foreign technologies and companies currently in the U.S. marketplace -- all of which demand attention. But we cannot simply be defensive.

As discussed, the technologies that will determine the United States' ability to secure its people and interests are overwhelmingly being developed for commercial purposes in the private sector. It is highly unlikely the government will create its own, distinct capacity to create and distribute these technologies in the near- to mid-term.

This leaves the national defense more dependent on the private sector than ever before, precisely as China is emerging as a true-peer competitor and rival economically, technologically and militarily.

All of this adds up to an unavoidable truth: the ability of the United States to invent, design, build, deploy and secure advanced technologies -- and their key components -- is as important to national security as the nation's capacity to field traditional military capabilities. With this in mind, it follows that new partnerships between the government and

industry are essential.

Finally, fourth, Conservatives must carefully balance their national security concerns regarding technology with their social and political concerns surrounding the growing role these companies have within our society. There are important debates to be had concerning perceived bias and other domestic political concerns associated with “big tech.” But, at all times, Conservatives must also remember that these same companies are likely to be the source of strategic advantage in the emerging global security contest, and so we must secure and shape our domestic tranquility without inadvertently destroying those who are producing the capabilities necessary for defending that same tranquility.

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Before joining AEI, Mr. Kitchen was director of the Heritage Foundation's Center for Technology Policy, where he led an enterprise-wide, interdisciplinary effort to understand and shape the nation's most important technology issues.

Before joining Heritage, Mr. Kitchen was national security adviser to Sen. Ben Sasse (R-NE) and worked on the creation of the US Cyberspace Solarium Commission, a blue-ribbon commission tasked with developing an American grand strategy for cyber. While working for Sen. Sasse, Mr. Kitchen served as the staff director of the National Security and International Trade and Finance Subcommittee for the Senate Committee on Banking, Housing, and Urban Affairs.

Mr. Kitchen has also worked on cyber strategy at the National Counterterrorism Center; as a senior program assessment officer at the Office of the Director of National Intelligence in the Office of the Director of Central Intelligence; and as the lead analyst on al Qaeda senior leadership at the Defense Intelligence Agency. He was also the National Counterterrorism Center chair at National Defense University.

A popular speaker, Mr. Kitchen has appeared on "60 Minutes" on CBS News and The New York Times podcast "The Argument." He has also been published in RealClearDefense, The Hill, The National Interest, The Telegraph, Washington Examiner, and National Affairs, among other outlets.

Mr. Kitchen has an MA in strategy and security studies from the College of International Security Affairs and a War College Diploma in security strategy and irregular warfare from the National War College, both from National Defense University. His BA in biblical studies is from Bryan College.

Chairman LUCAS. Thank you. And thank you to the entire panel for some very insightful thoughts and observations.

We'll now turn to the question session of the hearing. And I'll begin by recognizing myself for 5 minutes.

Dr. Droegemeier, in your testimony, you speak to how our democratic values and freedoms, freedom to discover and create, freedom to debate, challenge, speak freely, are the bedrock of the American research enterprise. Can you please elaborate on what makes the U.S. S&T network of government, academia, and industry unique and how these values contribute to our competitive advantage?

Dr. DROEGEMEIER. Well, thank you, Mr. Chairman. And I think Mr. Kitchen just beautifully laid out the important part of that argument. I think the thing about the interlocking nature of the four-sector enterprise—academia, industry, nonprofits, and the Federal Government—is the fact that there's a symbiosis. In fact, if you look at FFRDCs, which Dr. Budil leads one, these Federally Funded Research and Development Centers, the Federal Government does not run Lawrence Livermore Laboratory. A contractor runs it. The Federal Government does not run any FFRDC that I'm aware of. Basically, it—it has contractors operate it, so it keeps it arm's length.

That is just the opposite of what China does. As we just heard Mr. Kitchen talk about, China is deeply enmeshed in the business of innovation and development, and they basically make the choices of what is going to be done. They direct the work to be done. That's not the case here.

I think it's also certainly true that we have government labs and centers that do their own intramural research as well. But one of the most important things I think, ultimately—and I think everyone can speak to this—is the fact that there's a lot of open and freedom—openness and freedom to create new ideas and things like that. In fact, what happens in China, China tells the industries what they're going to do. Here, Congress listens, holds hearings, and we hear the Federal agencies responding to what the community says we need to do. The National Ignition Facility was not something that Congress said, hey, we need an NIF. We need to do it. It was the researchers, the scientists in the community. So the fact that we have this four-sector enterprise, it's not perfect. It's kind of clunky at times, but it works exceptionally well because the government does its role but they leave to the scientific and the research community the rest of the, you know, decisionmaking and what the priorities ought to be and where the innovation actually happens. That freedom is something that is super attractive, and it's one of the most important attributes that we have as a nation to wield against China in what it seeks to do in terms of global dominance.

Chairman LUCAS. Thank you. Ms. Wince-Smith, what are the benefits of having a National Science and Technology Strategy? And while you're thinking about that what are the key characteristics of such a strategy that will ensure that it's adopted and utilized by the entire U.S. S&T enterprise?

Ms. WINCE-SMITH. Thank you, Mr. Chairman. Well, first of all, I think it gives us the opportunity to have a unified vision. We're hearing, you know, very important parts of that in this hearing and

articulated by the Members. But right now, we have a splintered system. We have a lot of the economic issues that profoundly impact our science and technology enterprise being addressed in the Economic Policy Council, huge issues such as product liability, regulation, antitrust policy being addressed in another forum, issues around national security, and technologies that are totally dual use do not often get addressed in other parts. So we really need new mechanisms at a very coordinated level, first, for the government to get a policy in place that addresses things from the perspective of how does this impact our economic growth, our productivity, and our national security? Those are the three outcomes really.

And then what's very important about the United States and having a national strategy is we do have the mechanisms to bring our private sector in to help shape that through advisory committees, whether they're FACAs (*Federal Advisory Committee Act*) or, you know, temporary. I mean, the National Science Board is a wonderful example, at NSF and the Defense Science Board, but they're working on those sets of issues, not the overall strategy.

So I strongly believe, as did the people working in our National Innovation Commission, that we need an entity that works on this policy that has the same stature and power, quite frankly, as the National Security Agency in the White House, I mean, the national security policy and the other vehicles that address these domestic issues. But we need to integrate and cut across the sectors, and we're not doing that now, quite frankly.

Chairman LUCAS. Mr. Kitchen, in the time I have remaining, ideally, the quadrangle review process and development of the National S&T Strategy would be an opportunity to reevaluate partnerships between government, academia, and industry. Expand on why this is so critically needed and what outcomes we should seek for—from these partnerships—for these partnerships.

Mr. KITCHEN. Thank you, sir, for the question. I begin with the idea that there is no scenario under which the United States is able to secure its interests or its people absent a deep partnership with the private sector. The United States Government is now a national security stakeholder, not the national security stakeholder. Beyond dependency, private-public partnerships are our unique advantage. Government can focus and invest in core science that holds promise but that is not mature enough for the marketplace, while industry, using the dynamics of the free market system, can rapidly and efficiently create the innovations that people want and that will drive our economy forward.

The academy supports both of these efforts by advancing core knowledge and by producing essential talent. It is my view that this cooperation needs to be encouraged and to be made as frictionless and mutually reinforcing as possible.

Chairman LUCAS. Thank you. My time has expired.

The Chair now turns to the gentlelady from Oregon for 5 minutes.

Ms. BONAMICI. Thank you, Chair Lucas, and thank you to the witnesses.

One place where there's a tremendous opportunity to show leadership is in confronting climate change, one of the most important challenges of our time. And as we transition to a carbon-free econ-

omy, we need groundbreaking research and advanced technologies to effectively reduce emissions.

So Ms. Wince-Smith, in your testimony you noted that China has recently overtaken the U.S. in patents filed for nuclear fusion technologies. Do you have any sense of the relative strength and quality of China's fusion research enterprise overall in comparison to the United States?

Ms. WINCE-SMITH. Thank you, Congresswoman. I do not have expertise on the Chinese capabilities in laser energy fusion. I believe, Director Budil does. But what I do know is they're following the playbook of actually what Japan did some years ago, which is called patent flooding. They're filing a lot of patents around these areas hoping that they will then be able to fill them in with an innovation, and some of that will come from intellectual property theft and cyber attacks. So increasingly, China is using the patent system in order to steal and use technology from other countries and inventors. So that's one issue.

Ms. BONAMICI. Interesting. Thank you so much. And I'm going to follow up with Dr. Budil. In—of course to follow up on fusion first, we've heard a lot of talk from the Administration lately, and congratulations of course on the fusion integration just a couple of months ago. What a remarkable accomplishment. And I wonder, have we seen the willingness to aggressively pursue and support the development and commercialization? And what should future investments look like to continue U.S. leadership and advance research and technology at the pace needed to achieve our goals, including climate goals?

Dr. BUDIL. Thank you very much for the question. I think there are some very encouraging signs that there is very strong support for building on the momentum that's been achieved through science and technology advances across the fusion community in the last year, so that's both in inertial confinement fusion, which is the approach we take, and magnetic fusion energy, which is using tokamaks, for example. And there has been a lot of engagement between the Department of Energy, the Office of Science and Technology Policy, and the private sector to try to understand what the key questions are that remain.

Of course, investment lags. This, our fusion ignition breakthrough, was in December. So we're beginning now to formulate plans for what an investment strategy would look like to solve these critical problems. But across both approaches, materials challenges, understanding how to operate in radiation environments, understanding how to manage the fuel for fusion reactors, tritium, supply and then recycling and management, understanding balance of plant issues, how to get the energy out of the system and into the grid, and for inertial fusion energy (IFE), significant challenges going from a facility that was built to do national security research, one shot—high-yield shot per week to a 10-times-per-second energy salient ignition facility will be a very significant amount of research for which we don't currently have a substantial program in place.

Ms. BONAMICI. Thank you. Do you have sufficient workforce to do that?

Dr. BUDIL. We do have workforce, and I will say that recruiting is up in the wake of our announcement. Many people joined our lab to pursue this science because it's—they're very passionate about it. It's incredibly difficult and challenging science, but it's also—the potential benefits are incredibly galvanizing to students.

Ms. BONAMICI. To follow up on the workforce, you know, the strategy include—the law includes provisions to promote diversity, equity, and inclusion (DEI) in the workforce. Why are these provisions important in developing a national strategy broader than fusion, and how will including people of all backgrounds and experiences help us be competitive and support our efforts to maintain U.S. leadership?

Dr. BUDIL. Fundamentally, excellence depends on diversity, diversity of perspectives, diversity of ideas, diversity of backgrounds, disciplines, in every dimension. So if we want to be the best in any given field, it's important that we tap into the potential of all the people who have the inclination and the aptitude to pursue these fields. I really believe that fundamentally is critically important.

For science and technology fields like fusion energy, it's even more important because the number of disciplines we need to draw on is vast. The workforce that we need to generate to support this R&D agenda is very large. And so leaving people behind, making assumptions about which institutions or which people should participate is a fundamental barrier to progress in these fields.

At the national laboratories, we work very hard to ensure that we have broad and deep outreach programs to a wide variety of academic institutions, spanning 2-year institutions where we're generating technologists and technicians that support this research through to Ph.D.-granting institutions, including partnerships with HBCUs (historically Black colleges and universities) and minority-serving institutions, again, to bring along communities that have historically not been represented in the numbers that they should be in these disciplines.

Ms. BONAMICI. Thank you. And I see my time has expired. Thank you, Mr. Chairman. I yield back.

Mr. WEBER [presiding]. I thank the gentlelady.

And the gentleman from Florida, Mr. Posey, is recognized for 5 minutes.

Mr. POSEY. Thank you very much, Mr. Chairman.

Ms. Wince-Smith, in your written testimony you stated by increasing China's profile on international standards bodies, it aims to implement the Nation's China standards 2035 blueprint and Belt and Road Initiative for the next-generation technology. What can Congress do, particularly the House Science Committee, to ensure the U.S. maintains our leadership in the international standards bodies?

Ms. WINCE-SMITH. Thank you, Congressman. Well, standards have for many years been a nontariff barrier. Even our colleagues in the EU have used standards as a way to protect a different technology or innovation path from the U.S. in adopting standards. We have, as you know, a private-sector standards-driven process with various committees. NIST, our National Institute for Standards and Technology, plays a role. But at the end of the day, it's the private sector committees that develop our standards. They do not

have, quite frankly, the reach, the resources to participate in many of these critical standards bodies. So it's very important for us, in my opinion, to beef up the capacity of NIST and our private sector bodies to participate fully at scale because sometimes we only send one or two people to a standards body. And you look at the international organizations. I mean, China now is—is poised—and they may be the head of the IPO, the Intellectual Property Organization. So we need to invest and populate these international groups because the U.S. alone cannot do that.

And then also it goes back to what I said about technology statecraft. We need to work with our allies and partners, UK, Australia, Japan, India increasingly, and the EU on these standards that are so critical in the technologies that determine national security because all of these are dual-use technologies, quite frankly.

Mr. POSEY. Yeah, they like to play everybody's game, by their rules.

Now, Mr. Droegemeier, in your written testimony you had recommendations regarding National S&T Strategy and quadrennial S&T review. One recommendation is the need for skilled technical workforce. You know, I represent the Kennedy Space Center, and I've heard from companies that the need for these highly skilled technicians is really great. What policy changes do you believe are needed to help us maintain a pipeline of this kind of personnel?

Dr. DROEGEMEIER. Well, thank you so much for asking that question because it oftentimes goes unnoticed that the skilled technical workforce is really the underpinning of a lot of the science and technology development that we do. You look at large facilities like the Large Hadron Collider, you look at the LIGO (Laser Interferometer Gravitational-Wave Observatory) facility that had the—you know, the first gravitational wave. There are people—technicians who developed, you know, capabilities to have very incredible vacuums and things like that to keep these facilities going. They're skilled machinists that use 3D printing and other kinds of things. So they're very, very important. I think what we need to do—and we heard an example from Dr. Budil—that Lawrence Livermore on their own initiative, they reach out to 2-year and technical schools to incentivize the folks to do this. And I think we need to make sure not only are we resourcing them, but we're making clear the value that they have, that this is not just sort of a second-class citizen job. If you don't have a Ph.D., well, it doesn't really matter. No, these folks in many respects are the underpinnings of our S&T enterprise, so we need to have programs—the National Science Foundation has one in particular for the skilled technical workforce. It's—I forget exactly the name. It's something like something career tech education or whatever. But but those investments are very, very important across all disciplines to incentivize these folks coming in and showing the value that that they actually have.

Mr. POSEY. Ms. Wince-Smith, would you repeat your statistic that you mentioned earlier about graphite?

Ms. WINCE-SMITH. Ninety percent of the world's sourcing of graphite comes from China.

Mr. POSEY. Thank you very much.

Mr. Chairman, I yield back.

Chairman WEBER. The gentleman yields back.

And at this time the Chair recognizes Representative Lee.

Ms. LEE. Thank you, Mr. Chairman.

The passage of bipartisan *CHIPS and Science Act* with the largest investment in American industrial policy in the past 50 years and includes vast new resources to support entrepreneurship and technology and manufacturing, with an ambition of leaving no American behind. But this is because many Americans have been left behind in science and technology. Per U.S. Census Bureau, 90 percent of manufacturing firms are White-owned, 4.6 percent are Hispanic-owned, 4.5 percent are Asian-owned, and less than 1 percent are Black-owned. Within that small fraction, those Black-owned manufacturing firms are more likely to be less than 3 years old. *CHIPS and Science Act* looks to supersize scientific investment, and also promises new resources and policies to allow historically Black colleges and universities and other minority-serving institutions to participate equitably and genuinely in this research funding and in the entrepreneurship of wealth creation.

Understanding that innovation can often come from small companies that large companies then later buy, how can we ensure that equitable access to entrepreneurship in science and technology includes those small Black businesses and other small businesses from marginalized communities, Ms. Wince-Smith?

Ms. WINCE-SMITH. Thank you for that question, Congresswoman. I think you've raised, you know, an incredibly important issue for our country because, actually, one of our members at the council Michael Crow, President of Arizona State, said this, so I always give him credit. If you think of our Nation as a baseball team, we're only fielding less than 10 percent of the players whenever we participate in the game. And so we have to, as a nation, do everything we can to bring our entire population into the innovation economy of the future.

In terms of underrepresented ethnic groups, populations, one of the things I think that's very critical and it's underway is to integrate, for instance, our historically Black colleges and universities into large-scale research activities. We have a number of the presidents of these institutions in the council. They have capability to come in and participate in advanced project and quantum at another institution. That expands and builds up the capability.

In terms of the small businesses, we obviously have, you know, the Small Business Administration financing, but I think that one of the gaps, again, is on this place-based innovation. I am very excited about what's going on in some of our universities. For instance, I'll mention one, South Dakota State University. I just recently learned from the president that by the time you graduate, you will have, from South Dakota State University, all the capabilities for the top clearances to work in cybersecurity. So we need to look at all these universities and ensure that we have a path for all our citizens.

And I want to just mention on the issue of the labor unions, and I was whispering this to Dr. Budil. The pipe fitters and plumbers union is still at NIF. They built NIF. They operate NIF. These are highly skilled workers. And having this collaboration between our unions and our companies is very, very critical to this strategy of building out a very diverse, inclusive economy.

Ms. LEE. Thank you. In my home district, Pittsburgh, we've been turning the corner from more manufacturing industries, steel, to a tech hub and innovation hub. One such business that we have in Pittsburgh is a company called Astrobotic. It's an employee-owned company, with a goal of making unmanned space missions feasible and more affordable for science. Dr. Budil, Astrobotic is—it's actively competing with Lockheed, Elon Musk, and Jeff Bezos. Space exploration and advancement of technology and science should not be limited to billionaires. So what steps do you believe we can take to ensure that organizations like Astrobotics are not outliers in science and technology?

Dr. BUDIL. Thank you very much for the question. It's a very important one. When we think about partnering with industry, we think about it in different tiers. So we commercialize technologies, meaning we spin out technologies, so we work with startup companies. We work with small- and medium-sized companies. We bring them to the laboratory so that they can have access, in partnership with our researchers, to our facilities and capabilities to help increase their capacity to compete. And then we work with large business as that may be appropriate to the technology that we're talking about. So we have active programs in ensuring that our capabilities are well-understood in the broader community and that we have mechanisms in place where we can bring small- and medium-sized companies to bear.

I'll cite two examples. One, we have a program for the application of high-performance computing in manufacturing and other areas where companies can apply to work with our researchers to have access to our machines and our simulation tools. And a second, we have an advanced manufacturing laboratory where we have laboratory space specifically designed to bring academic and business partners into the facility to work with our researchers again to advance their technologies and enhance their competitive prospects.

Ms. LEE. Thank you. Thank you, Mr. Chairman. I yield back.

Mr. WEBER. The gentlelady yields back.

The Chair now recognizes Dr. Babin from behind the Iron Curtain.

Mr. BABIN. That's east Texas. Thank you very much, Mr. Chairman.

Thank you, Mr. Chairman, Ranking Member Bonamici, for organizing this incredibly important conversation that we're having today. I want to thank all of you witnesses for being here and taking part with your expertise.

When we talk about investment in our research and technology, it's equally important to talk about how we protect it as well. It's no secret that, for years, the Chinese Communist Party has stolen American intelligence, technology, and intellectual property in their relentless pursuit to supersede us as the No. 1 superpower in the world. So how do we make sure that our S&T is better protected, and what should our approach be? And that is what I want to focus on today.

And, Mr. Kitchen, in your written testimony, you describe the U.S. approach to the geopolitical race for technological advancement as engage and invest, whereas you refer to the CCP's tactics

as fuse and use. And the U.S. approach of engage and invest the best option for our long-term—excuse me, is the U.S. approach of engage and invest the best option for our long-term completeness? And are there any lessons that we should take away from the CCP's fuse-and-use tactics?

Mr. KITCHEN. Thank you, sir, for the question. I think the only lesson that I would recommend from the Chinese model is that it spreads the national security burden across its public and private sector. But the CCP does this through coercion and for economic reasons as well, and we do not want to do that. What the U.S. should do, however, is forge voluntary, public-private partnerships that are based on a love of country, common interests, and our shared fate. American technology companies have worked very hard to gain their geopolitical influence, and it's now time that we help them wield that influence responsibly.

Mr. BABIN. Thank you very much. And one more. While China's R&D expenditures have grown exponentially, I understand that 84 percent of that nearly \$500 billion R&D expenditure is on development, and only 5 percent is on basic research. How does the United States' emphasis on basic research give us an advantage in the long term to compete, to collaborate, and to thrive?

Mr. KITCHEN. Sir, I think the key point here is that China essentially crowdsources their R&D by stealing the IP and data of other nations and then spends the bulk of their time and resources on turning the stolen treasure into capabilities. Basic research is exactly that. It is the foundation on which everything else rests, and if we do not continue to replenish that basic research, our innovation will grind to a halt, a little bit like expecting your car to run forever because you filled the gas tank last week.

Mr. BABIN. Absolutely. Thank you.

Mr.—Dr. Droegemeier, I was pleased to have worked with this Committee on getting one of my bills, H.R. 3747, included in the *CHIPS Plus* bill that passed last year. My bill will establish a pilot program to ensure the security of federally supported research data and to assist regional institutions of higher education and their researchers in safeguarding our sensitive information. You mentioned in your testimony how the *CHIPS Plus* bill provides the opportunity to compete against China. Can you please elaborate on that and how we can simultaneously protect our S&T research?

Dr. DROEGEMEIER. Well, thank you so much for the question. And, Mr. Chairman, I'd like the record to show that an Okie is having a good conversation with a Texan here. OK?

Mr. BABIN. Yes, sir. We appreciate that, too.

Dr. DROEGEMEIER. It's very, very important—

Mr. WEBER. It's noted in the record.

Dr. DROEGEMEIER. Thank you, sir. It's a very, very important question. It's the balance between protect and promote. And I think the key thing in terms of the protect side is to make sure that we have the capability for our institutions, whether large or small, to have the resources they need to vet the individuals and companies and others that they're working with. You want to make sure—if you're a bank and you're giving a loan to somebody, you want to know what their background is. You want to know their capability to repay. We don't do, I think, a good enough job to do that. We

need to make sure we know who we're working with. The fact that they arrive on our campuses doesn't mean that they don't have, you know, undue influence on our system. So we need to educate, we need to provide resources. In the *CHIPS Act*, the National Science Foundation was charged with standing up a research, security, information-sharing and analysis organization. NSF is in the process of doing that now because universities and colleges aren't equipped to, you know, answer the kinds of questions that that type of facility will be able to answer.

So I think we need to educate, we need to train, we need to create vigilance, but we also need to promote our values. And folks that come here from other countries, we need to model those values and talk about the consequences for not adhering to those values. And when we all play by the rules and they see the importance of that, because I think most people long to play by the rules, there are some bad actors out there, you know, but I think those are the kinds of things we need to do to balance the protection of our research assets with promoting them.

And the last thing we want to do is have China say boo, and we jump and tie our own hands.

Mr. BABIN. Right.

Dr. DROEGEMEIER. That's exactly the wrong approach.

Mr. BABIN. Absolutely. Thank you. I have one more question, but I'm out of time, so I will yield back. Thank you.

Mr. WEBER. The gentleman yields back. I appreciate it.

We now recognize Representative Ross for 5 minutes.

Ms. ROSS. Thank you, Mr. Chairman. Thank you for holding this hearing and to the Ranking Member. And thank you to all the panelists for joining us.

I'm delighted to be holding this important hearing today because last Congress, I worked with my colleague, Congressman Waltz, who previously sat on this Committee, to pass the *National Science and Technology Strategy Act*, and it was signed into law, as you know, as part of the *CHIPS and Science Act*. This legislation created the whole-of-government planning process for research and development, ensuring better coordination between Federal agencies and a more strategic approach to U.S. research and development goals. It also requires the President to submit a report to Congress on national research priorities and activities, as well as global trends in science and technology, including potential threats to the U.S. scientific research and leadership.

I represent part of the Research Triangle in North Carolina, which is a hub of innovation, and it's home to some of the world's top research universities and institutions. Collaboration between public and private entities to advance American research and innovation is a top priority for me, and I look forward to hearing from all of you about that.

I do want to pick up on one of the comments that was made earlier, though, about technical workers and the work that we need to advance all of the great STEM innovation that we're having. And I'm pleased to say that the head of the National Science Foundation came to North Carolina right before Thanksgiving and spent more time at our technical community college than he did at our greatest NSF receiving grant institution. Now, of course, I rep-

resent them both, so I was happy for him to be at both places. But, as we know, these workers don't need to just have 4-year degrees. And in North Carolina, particularly in Wake County, we have a pretty sophisticated community college that has gotten three NSF grants. But not every community college has the ability to do that. And we do know that there is more technical assistance to our community colleges.

But if you could elaborate on how we should really reach out and embrace our community colleges that will be preparing these workers, perhaps by targeting locations where we know we're going to need those workers for strategic purposes, perhaps partnering with our 4-year institutions. And I'll just open it up to all of our esteemed panelists for any suggestions that you might have and how we can help advance that in this next Congress. Yes, please.

Ms. WINCE-SMITH. I'll start. The community colleges are absolutely an essential part of our educational infrastructure in the country. And what's increasingly happening with some of these colleges that's very strategic, they're also working with the skilled labor unions, so they have partnerships now that are integrating that. But also, I think, on the community college front, the Department of Labor—you know, this is an example of not having this overall system of coordination. They have, you know, millions of dollars that go into workforce development boards in each State and aligning those with the needs of business, the future jobs, how the unions participate, and how the community colleges have to do that additional advanced training is very, very significant. And the community colleges have an incredible track record of their graduates getting jobs right away, so they are essential.

And we have in the council a group of university president leaders, and Jere Morehead, the President of the University of Georgia, said we need to work at the college level more with the workforce in our regions. And I think that's another example of this recognition of how these all things—these things all come together in a system.

Ms. ROSS. Could anybody else elaborate on getting this NSF money into the community colleges as well? Because, like I said, Wake Tech has been very good at that. But we would love, love to have that spread around more.

Dr. DROEGEMEIER. Yeah, in fact, your point is right that a lot of 2-year colleges don't really know much about working with NSF and so on. And this gets to a point that was made earlier about diversity. We'd like to think about giving money out to all these different organizations, but a lot of times they don't have the fundamental capabilities to manage a grant award. And we sort of set them up for failure. If they're an audit risk, and all of a sudden, something goes south, they're caught in a really bad place. So one of the programs NSF has started recently is a program to basically create a community of research administrative personnel who can work across all kinds of different institutions to bring those to the table who aren't now currently participating. So if you're a 2-year college, you don't have to develop all that stuff yourself. You can partner with somebody who can help you do that. That really empowers and resources you to do it without you having to make all kinds of investments that you really can't afford.

Ms. ROSS. Thank you, Mr. Chairman, and I yield back.

Mr. BABIN [presiding]. And I would like to recognize the gentleman from California, Mr. Obernolte.

Mr. OBERNOLTE. Thank you, Mr. Chairman, and thank you to our witnesses.

Mr. Kitchen, I'd like to start with you. I find your testimony on Chinese intellectual property theft incredibly compelling. You characterize it as one of the largest thefts of wealth in human history, which is a way that I hadn't put it—I hadn't heard it put before. You also mentioned the importance of confronting Chinese intellectual property theft. That's obviously more easily said than done. What exactly do you think we could do to confront that, and what specifically can Congress do in that mission?

Mr. KITCHEN. Thank you, sir. The statistic about the largest transfer of wealth in history is a quote from FBI Director Wray. And he's been very forthcoming about his assessment of the situation. I would align myself with that assessment.

In terms of confronting Chinese theft, there's a host of things that we can do. One, we can begin enforcing our intellectual property rights and laws internationally, using that as a point of negotiation, international engagement with the Chinese Government and international standards-setting—standard setting, settings—as well. But frankly, there's a lot lower-hanging fruit that is—can be difficult domestically, and I briefly alluded to them. And that is we are being willingly robbed blind daily by the presence of Chinese technology companies in the U.S. marketplace.

And I want to be clear when I talk about this. I am not accusing every Chinese-origin technology company as being malevolent. They don't need to be malevolent. They simply need to be compliant with Chinese law because Chinese law is explicit and very clear. The Chinese Government has been very kind in publishing their law, their national security law, their cybersecurity laws in English because they expect U.S. companies to comply with those laws. And those laws are very clear in the fact that they require that every bit and byte of data that is collected by, transferred, stored on, or in any other way touches a Chinese network or the network of a company that is owned by a Chinese company to be made available to the Chinese Communist Party. That is not ambiguous. That is not unclear. That is a fundamental requirement of operating in the—in China.

And so we need to recognize that and confront it. Now, not all industries are the same. So I'm not arguing for a reckless decoupling. But to answer your question directly, sir, if we want to begin to protect not only our intellectual property and our individual data, there's some pretty obvious doors that we need to close. And I'm happy to see that conversation advancing in the public sphere.

Mr. OBERNOLTE. OK. Thank you. Your thinking aligns with mine in a number of different degrees. This is an area that I also think needs a lot of attention. I've got a bill to enable extraterritorial prosecution of Chinese companies and individuals that engage in theft of intellectual property from U.S. companies.

I'm also very concerned about Chinese components in the Internet of Things (IoT). I think that that's something that we haven't paid enough attention to, you know, the fact that we've got

doorbells and refrigerators and toaster ovens and garage door openers, all collecting information about us that could be shared with malign actors who could put that data to malicious use. Do you share that concern?

Mr. KITCHEN. I absolutely do. In fact, there is a Chinese IoT platform as a service company called Tuya, which dominates globally and the United States approximately 70 percent of the marketplace. So what that means is, is that if you are a—you know, a light bulb company, and you want to begin making smart light bulbs but you don't know how to do that, you will approach Tuya and they say we got it, we can turn your light bulb into a smart light bulb and give you a platform for managing that capability.

The problem with that is that it, as a Chinese company, is—needs to be responsive to the laws that I just previously outlined. So what that means is, is that this Nation might have done a great work by removing Huawei, for example, from its 5G networks, only to then allow Chinese-owned IoT devices to continue collecting the same information we were trying to protect.

Mr. OBERNOLTE. Right. Thank you.

Dr. Budil, good to see you again. Congratulations, again, on your success at NIST. It's an amazing leap forward, and I think that, you know, really, this is going to be—we're on the cusp of like an inflection point in fusion research as a result of the work that you're doing. But just briefly, I can see I'm almost out of time, you've highlighted the need to—for continued investment to create—to increase the yields on the fusion ignitions that you're achieving at NIST through the inertial confinement technology that you're working on. Commercialization though, I think, is going to center more around magnetic confinement than inertial confinement. So can you just take a minute and explain why continued investment in inertial confinement is a good use of taxpayer dollars?

Dr. BUDIL. Yes, thank you very much for the question. It's early days for the inertial confinement fusion energy application, mostly because we just achieved fusion ignition, which is the foundational building block for that technology. I think you'll see a rapid growth in the IFE community, and there are several companies with significant capacity that have already entered the marketplace on our technology, so we'll see how the next few years play out.

Inertial fusion energy has a couple of advantages as an application. One is that the energy-generating source is separate from the driver so we can develop both of those in parallel. But to your point, the magnetic fusion community has had a much more significant footprint in the private sector and has some significant runway there. I think the promise of inertial fusion energy is very significant. The facilities that we have are built for national security applications, so if we really want to understand what's possible in the next few years, it's very important that we—that we begin to invest in the energy applications and understand what the possibilities are there.

Mr. OBERNOLTE. Well, we look forward to your continued success. Thank you, Mr. Chair. I yield back.

Mr. BABIN. Thank you.

Now, I'd like to recognize the gentleman from New York, Mr. Bowman.

Mr. BOWMAN. Thank you so much, Mr. Chairman.

Dr. Budil, thank you so much for being here, and thank you for the briefing you provided to us a few weeks ago.

Fusion ignition, like, wow, like, the first time in human history this has been done. Like, can we all just take a moment and recognize this? Everyone's up here talking fast and trying to get through questions. I just want to acknowledge how extraordinary this is and just recognize you for your incredible leadership throughout your entire life focusing on this issue. Thank you so much. And when I read about this, I thought I was reading something from a science fiction novel or watching a Marvel movie or something. Can you talk about and summarize for us what this accomplishment can mean specifically for our clean energy future?

Dr. BUDIL. Yes, thank you very much. And yes, it never gets tired, never gets old to hear people say ignition. So basically what happened in the experiment that we did in December is we used 2 megajoules, 2 million joules of laser energy, to create over 3 million joules of fusion energy out of the target. And that's the first time in history that more fusion energy has been produced than the energy required to drive the experiment across any approach to fusion, so that's incredibly important. We built this facility and we have been on this research path for our national security applications, so that process of developing and igniting target and increasing the yield is critically important to the Stockpile Stewardship Program.

In order to begin to think about energy applications, we need to think about some additional challenges. The targets that we use to do these experiments are beautiful, exquisite works of art. In order for this to be viable as an energy source, we need to be able to make these targets very robust, higher yield, and much simpler to manufacture and produce. We need to move from a system that produces one fusion ignition shot a week to having the capacity to do that repeatedly, ultimately, 10 times a second. And we have many of the component technologies that would enable that, but until we had this fundamental building block, we couldn't really begin to move on some of the key questions that stand between what we've done to date and a potential energy application.

If we are successful, it is feasible to develop a fusion energy—fusion energy power plant based on the inertial fusion energy approach that could be commercially viable. Again, we're making extrapolations based on what we know today. There's a lot of work to be done. And I will say it's not just engineering at this point. There is still physics to be explored and to learn from, but that includes, you know, advanced laser technologies, tritium management and recycling, balance of plant issues, materials for radiation environments, et cetera.

If we're successful, fusion holds the promise of providing base-load-scale energy, clean, without many of the long-term waste concerns that have been raised around fission technologies. So it has an abundant fuel source and can work at scale, independent of location. So most of the renewable energy is very regional in character. Fusion really is a clean baseload source of energy.

Mr. BOWMAN. That's incredible. It feels like this is a moonshot moment for us. And we need a moonshot-style national effort to

make fusion energy a reality. Do you agree with that? Let's move heaven and earth, all-of-government approach, private sector. This is our moonshot moment.

Dr. BUDIL. I agree with that. We have spent 60 years creating this fundamental building block. We will continue to pursue this R&D for our important national security applications. But the prospects for energy are real, and they will require a whole-of-nation, private-sector, public-sector, community-based approach to advancing the science and technology here. And we have demonstrated in the past with efforts like this what we're capable of as a nation when we bring together the best minds, the best technology, the best elements of the private sector and the public sector. And this is an incredibly exciting challenge. So, as I mentioned earlier, students are really energized about the prospects for fusion, maybe pun intended. And so there's—there is a willing body of intellectual capital that's ready to move on this problem if the resources are available to make it move forward.

Mr. BOWMAN. Dr. Droegemeier, can you add anything to what was just stated?

Dr. DROEGEMEIER. I'd just like to clap. I just think this is—

Mr. BOWMAN. Are we allowed to clap in the hearing room? I think we should clap. Yes, we can do that.

[Applause.]

Dr. DROEGEMEIER. I have to underscore the point that that she just made, though, 60 years. That's taking the long-haul view, right? That's being patient, investing, investing in something, and now all of a sudden, we have this extraordinary thing, not only for our national defense capabilities, but also for the future of our energy. And that's just I think a beautiful, beautiful thing. Thank you.

Mr. BOWMAN. I yield back.

Mr. BABIN. Thank you very much. And absolutely, congratulations. That information certainly needs to be protected as well as we go forward into that research.

I'd like to recognize the gentlewoman from Oklahoma, Mrs. Bice.

Mrs. BICE. Thank you, Mr. Chairman, and I thank the witnesses for being here this afternoon. And a special shout-out to Dr. Droegemeier, who is my fellow Oklahoman.

I want to direct this first question to Ms. Wince-Smith, and that is in your opening statement you talked a little bit about the valley of death. And I had a opportunity to sit at a roundtable yesterday with Chairman Lucas, with technology innovation owners that are trying to really, you know, ensure that we have superior capabilities over our adversaries, including China. But that was also brought up. What do you think we as Congress can be doing to try to bridge that gap, whether it's existing programs that need to be modified or other ways that we can continue to promote that type of needed innovation?

Ms. WINCE-SMITH. Thank you for that very important question. And I have to say, I've been working on this issue for most of my career, so I hope someday I'll never hear valley of death.

One of the issues is that we do not have a financing system in the United States that moves beyond the initial kind of startup phase into manufacturing. And I'll just share an example. Back in

the nineties and even earlier, this country invented every single flat panel display technology, the first being liquid crystals out of Kent State, plasma, field emitters, the list went on. And there was lots of venture capital coming into that. But then it was time to make the manufacturing plant and scale it up. Not a penny. All of that went to Asia. We have the example of A123 battery. More, hundreds of millions went into that, including from the Department of Energy, the State of Michigan. Again, it was the manufacturing scaleup that takes lots of money.

So we have to figure out in our country a way to bridge that. It's not going to be from traditional venture capital. Our banks are not engaged in this. There are no incentives for that. We have called at the council for many, many years for a national infrastructure bank. Many countries have that where they could make these large-scale investments on the manufacturing side. And this is very relevant to commercializing the fusion. It is an all-nation hymn. We're not going to get to where we could if we don't have massive investment from the government and private sector.

But on the valley of death we really need to have some expanded programs, including SBIRs (Small Business Innovation Researches). There are companies that just spend their time getting SBIR grants. It's kind of an industry. And I can tell you when I was Assistant Secretary of Commerce, there were groups outside the United States who would look at those SBI awardees. They knew they couldn't go after stage B, and they'd come in and acquire them. And that's happening now in Silicon Valley and elsewhere. So having SBIR stage C that takes it farther on is one mechanism. And the States could actually contribute that as well. It doesn't need to be just Federal.

So it really requires new models and really moving out of our traditional mode of thinking, oh, we have the great—we do have a great venture capital industry, but they don't invest in the kinds of things we're talking about here.

Mrs. BICE. Happy to open the question up for any of the other witnesses if you'd like to comment. If not, I'll follow up on another question.

OK. The second question is that, you know, America's economic future is dependent on successfully driving innovation and productivity growth in all parts of the country. What role will regional innovation initiatives have in securing U.S. leadership in research and technology? And this is open to any of the panelists.

Dr. DROEGEMEIER. I think regional innovation is key. And again, back to the diversity question, we need to bring the technological capabilities and development opportunities to those regions because we want to transform the regions. We don't want to take the people out of the regions. Maybe their families have been there for 50, 60 years. We want to lift those regions up. And so I think that the regional and and sort of, I think, as we heard, the place-based innovation is really critical.

NSF is doing this now with the EPSCoR (Established Program to Stimulate Competitive Research) program. I think a lot of you are familiar with this. Whereas before it was, hey, how can we help, you know, increase the research competitiveness? Now, the focus is on what they're calling jurisdictional transformation, get-

ting the universities, getting the small business community, getting the Federal—getting the State governments rather, getting the chambers of commerce together and saying, how can we transform our entire State using science and technology? Oklahoma's a very rural State. North Carolina is a rural State. There are a lot of great opportunities to do innovation, to get these folks involved. But we have to really think about, you know how to resource that and do that and build these partnerships at the State level in particular or in the regional level as well. And I think that's really a key to our future is not just doing it at the well-resourced places but having every zip code of the country become involved.

Mrs. BICE. Thank you, Mr. Chairman. I yield back.

Mr. BABIN. Thank you.

Now, I'd like to recognize Ms. Salinas.

Ms. SALINAS. Thank you, Mr. Chairman. And thank you to the panel.

Climate change is a uniquely unifying threat across scientific disciplines and across nations. And I'm proud to represent the Oregon's Sixth Congressional District, a State that has long taken climate concerns seriously. And while each State and nation is dealing with its own climate consequences based on its infrastructure, geography, and economy, it's not really a problem that can be dressed—addressed in jurisdictional isolation. And so when it comes to climate, remaining competitive on the global stage necessarily involves fostering international collaboration with disadvantaged nations on the frontlines of sea levels rising, as well as with scientifically sophisticated competitors who may have a more mature climate strategy.

And so my questions for the panel, first, when it comes to competing with China and the need to address climate change, what does that global leadership in science and technology development look like? And then I'll give you my second question. And then how can the U.S. best build upon the progress of other nations, including competitor nations? And it's generally to the panel, to whoever would like to answer.

Dr. DROEGEMEIER. I guess I'm the climate guy. So with regard to science and technology development, I think it's—there's no question—and we haven't really talked about this yet. But in terms of the research in our Nation, I think the importance of Chinese nationals coming to study here is very, very important to our future, again, an opportunity to lead with our values, to be constructively vigilant, to model for these folks, you know, what playing by the rules actually looks like. And when I was at OSTP I asked the question, suppose we just shut off all the immigration instantaneously? How long would it take us to get to where we would be otherwise? And we're talking generations. So we really have to collaborate.

The climate challenge is a very important one for which I think they're—certainly, as you say, it's an international problem. Part of the problem, though, is that China is a huge global emitter, and it's building coal-fired power plants in other countries for reasons we've heard about previously, but that does not get counted against China's contributions to greenhouse gas emissions. So I think we need to, again, have China be honest about what it's doing, and

say, OK, if we're going to really solve this challenge, technology and research are part of it, but also, mitigation is another very important part of it. And getting China to own up to the fact that, yes, it might be emitting, you know, twice as much as us with regard to CO<sub>2</sub> or whatever, they're actually emitting a whole lot more than that because they're putting these plants in other countries and getting a foothold there in their energy systems and also their data systems, so it's a very kind of nefarious thing.

So I don't know if that answers your question, but, as an S&T enterprise, we really do need—we need a global approach here, and we need researchers from China working with us on the climate challenge.

Dr. BUDIL. So I'd like to add, we have really formidable capacity in the U.S. to understand how the climate is evolving and what the impacts will be to nations in the developing world in particular. And we have an opportunity to build partnerships, science and technology cooperation partnerships, with many of those nations to help them understand what the impacts are that are coming, what the technology solutions are that are available today that could be deployed, and there are many, and to help them identify strategies to sustainably transition their energy supply.

I think this idea of thinking about S&T as a bridge-builder, you know, that's—S&T cooperation with allies and partners at scale, that's what the developing world, Europe, our traditional partners in the UK, in Asia, in Japan, in Korea and Australia, India, but also working with these smaller nations to help them build capacity and to really use the fruits of our research enterprise to help them develop more sustainable paths forward and to use that as a way to increase U.S. influence in how these countries think about their future.

In climate modeling, we have the capacity today to really understand at a very local level what the impacts are likely to be over time. And so I think this is an underappreciated form of international diplomacy and U.S. leadership that we should be exercising.

Ms. WINCE-SMITH. I would just add—and it's a wonderful opportunity for our agency, for international development, and sister agencies around the world to collaborate on this and to leverage what they're doing in different parts, particularly in the developing world, as opposed to a lot of those programs kind of operating in silos.

Dr. DROEGEMEIER. If I can just add quickly, the *Weather Act* that this Committee will reauthorize, I believe, has a lot of provision in there for work at the weather-climate interface. So we're talking about these developing nations, these other nations, their economies may be very agrarian. The very local effects are what are important, so it sort of is not just the 2-week weather timeline but the timeline out to several months. And, you know, a couple of planting seasons is very, very important. So this kind of research is really the key point. And if you think about reauthorizing the *Weather Act*, you might want to think about really highlighting that point.

Ms. SALINAS. Thank you. I yield back.

Mr. BABIN. Thank you.

I'd like to recognize the gentleman from Georgia, Mr. Collins.

Mr. COLLINS. Thank you, Mr. Chairman.

As a freshman, newly elected, been here about 2 months, and spent 30 years in private business as a small business person.

Ms. Wince-Smith, I heard when you were speaking earlier, you talked about a unified vision and economic issues and public liability and regulations and antitrust. And I look at it as a point of we can compete with anybody in the world in small business. And I took that personally as the same things that I saw in small business as an overreach from our Federal Government, regulations and bureaucracies out there that really regulate most businesses to the point where they can't compete or they have to look for outside sources.

And I guess my question in a nutshell is do you think that the government overreach and excess regulations are hindering our ability to compete with China?

Ms. WINCE-SMITH. Thank you for that very important question. And, you know, regulation is always a balance issue. It's sort of like the golden mean. We do need regulation, but we don't need too much regulation, and so how we get to the right point is the challenge. And certainly, we in the United States have overregulated in many, many areas vis-a-vis our competitor, certainly China. I mean, they're on the side where they don't regulate. I've been told if you go to a facility where they're actually processing rare earth materials, you think you're in a different age, a different place. I mean, there's absolutely no regulation whatsoever on safety, health, environmental, so it is a balance issue.

But I think on some of the regulation in the United States, we're—it's almost like we're Gulliver, and the Lilliputians are tying our hands because product liability reform has gotten to the point—and we've tried over the years to reform this as a bipartisan issue. But if you produce a chemical, as a small business, and one of your customer buys it and something happens through what they did with it, the liability goes all the way back to you. So we know that many, many corporations in the United States actually stopped production and moved overseas because of the punitive nature of our product liability. And again, it's a balance issue. So I do think that this is a matter that we can have, you know, the best science and technology, we can have lots of startups, but it takes regulation, it takes capital, it takes trade to get these into the marketplace. And these are issues that we need to work on. And in many, many ways we have overregulated. We need to bring that back but still protect safety, environmental health, and the transparency of a business for its consumers.

Mr. COLLINS. Hold that thought. Mr. Kitchen, did you want to—could you add to some of that? I knew you gave several examples like the doorbells and stuff.

Mr. KITCHEN. Thank you, sir. I think the thing that most concerns—so I would align myself with everything that was just previously said. I think, obviously, some type of regulatory regime is essential. It's what sets us apart so that, you know, our airplanes typically don't crash, right? And that's in large part because of the regulatory infrastructures that we have. At the same time, we are playing a balancing game as we try to allow our innovation indus-

try to run free and to be aggressive and agile. That's a critical capability. So these are the balancing acts.

I think when it comes to regulation, one of my most fundamental concerns, as I mentioned in my testimony, is where many of our allies and partners are going. To be frank, many of these allies and partners seem to think that the goal is to produce as robust and aggressive a regulatory scheme as possible. Instead, I would argue that the goal should be to produce as robust and as aggressive innovation capability as possible. And so when our friends in the European Union and even to our north in Canada are considering explicit policies that deliberately seek to decouple U.S. technology companies and that will have the net benefit of preferencing Chinese alternatives, all under the guise of digital sovereignty, I want to express a type of empathy with their underlying motivations but warn them as a friend, you're doing it all wrong. And that if that's not arrested and brought into a better sense of things, it will result not only in hurting the United States, which is bad enough, but it will preference and allow China to move in and assume a position that it will almost assuredly abuse.

Mr. COLLINS. Thank you, Ms. Wince-Smith, one quick question. Ninety percent of the graphite is found in China, produced in China, or just refined in China?

Ms. WINCE-SMITH. It's coming out of China both refined—I don't know if it's all produced. But I just heard this from a very exciting startup battery company. And—

Mr. COLLINS. So they don't have 90 percent of the graphite—

Ms. WINCE-SMITH. Not in the world, no, but it's coming from them. And they have the processing—

Mr. COLLINS. And I would say that's probably—

Ms. WINCE-SMITH [continuing]. Capability—

Mr. COLLINS [continuing]. Due to permitting regulations and mining restrictions—

Ms. WINCE-SMITH. Big, big part of it.

Mr. COLLINS [continuing]. Right here. Thank you. I yield back.

Mr. BABIN. Thank you very much.

I'd like to recognize the gentleman from Florida, Mr. Frost.

Mr. FROST. Thank you, Mr. Chairman, for convening this important hearing, and thank you to our witnesses.

Look, I believe that the greatest challenge facing our country and the world is the climate crisis. My generation fears that we will lose drinkable water, breathable air in our lifetimes, and worry that our childhood homes will be flooded out by the sea level rise and food will become scarce. And this is especially important in my State of Florida. We're a frontline community. As you know, last year, we had two storms that completely decimated and wiped out many of our coastline cities. It was a great issue in my district.

One thing that the United States can do right now is lead the world in science and technology advancements to help prevent the climate collapse. And I believe we have to enact near-term solutions and develop long-term strategy to make sure that the U.S. science and tech fields can meet this challenge.

So Dr. Droegemeier, I wanted to ask, how could this National Science and Technology Strategy address near-term resilience goals and also long-term prevention goals to address the climate crisis?

Dr. DROEGEMEIER. Oh, it's an excellent question, and I think that's exactly the purpose of the strategy. And frankly, that's why I think the 4-year timeline is great because it's kind of the same as the National Climate Assessment, but also putting in the context of a 25-year horizon where it goes beyond elections and beyond, you know, beyond the normal thing, and people say, well, we've never done that before. That's the whole point, you know? A meteorologist telling you to do a 25-year forecast, that's not what I'm saying. I'm basically saying let's think long term about the overarching, broad S&T issues and the kinds of things that we want to do as a Nation, not the specifics, you know.

So with regard to the S&T, you know, very simple climate models tell us that you increase greenhouse gases, the planet will warm. We don't need all the sophistication. We do need the sophistication, though, to know what the localized impacts are. We don't do a great job with that to be honest. The error bars on the actual projections are pretty large, but we are doing a lot of work, I think, to improve those. So the models are basically all that we have. And the thoughtful approaches as to how the population will grow, what the technology mix will be, and things like that, all these different scenarios that are played out.

So I think from the the short term we need to think about, you know, measures that are mitigation-adaptive. You look at a lot of the—a lot of commercials on TV now, everybody's doing EVs, right, because we're starting to have infrastructure that will allow that to happen with our power grid. The longer-term things, if you look at the models, the greatest uncertainty in the short term is the actual atmospheric uncertainty in the model itself, the actual natural variability. You get beyond 20 years or so, the great uncertainty is in the energy mix and the population and all that sort of thing. So I think we need to continue to study those things, take even more thoughtful approaches, and look at improving the physics of the models, building—you know, I would love to see us in this country build a—what the Japanese did 20 years ago, an Earth simulator, a computer designed specifically—

Mr. FROST. Yeah.

Dr. DROEGEMEIER [continuing]. And Livermore could be the perfect place to house this.

Mr. FROST. Yeah.

Dr. DROEGEMEIER. Really—you know, we write our codes in a way that has to adapt to transaction processing computers just because that's what is out there. You know, suppose we as a nation said we're going to put \$2 billion into building a computer designed just to simulate the Earth system and do what no other Nation can do in terms of climate projection, that would be an enormously valuable investment because we have the capability, but we don't have the computational capability to run these models at the resolutions needed to capture clouds and hurricanes and things like that. We're just waiting for computing to get there.

Mr. FROST. Yes.

Dr. DROEGEMEIER. Let's fast-forward computing technology and build something as a nation that would get us there.

Mr. FROST. Thank you. No, I really—and that leads to my next question, you know, the other benefits of this work.

Dr. Budil, I wanted to ask, so Orlando where I'm from, we're quickly becoming the simulation hub of the country, which is really exciting. We actually—I was just at the Orlando Economic Partnership, which is an organization, and we have the first city digital twin, a complete digital twin of Orlando, which is going to be great. I wanted to ask what—do you believe advancements in computer simulation technology to model the impact of climate change could give us a competitive edge?

Dr. BUDIL. Yes, thank you for the question. It's an excellent line of questioning, and I agree completely. And I agree with my colleague's comments entirely. The Department of Energy has been on the frontline of advancing the state-of-the-art in climate modeling for some time and is currently developing the ESM—3 (Earth System Model) code, which is the Earth system simulation model, a next generation that's anticipated to run on our new largest computers.

So Oak Ridge has just sited Frontier, which is a large exascale computer. Livermore will be home to the first exascale computer, slated for national security applications. It will also do open science applications like climate, and it'll produce at over 2 exaflops. So we're beginning to have the computing capacity and the modeling and simulation tools to do this work. It's going to be incredibly enabling.

And with the introduction of tools like artificial intelligence and machine learning, we're able to advance the capabilities of our models very quickly relative to what we were able to do in the past. By taking onboard large amounts of data, we're getting much more data at higher fidelity about different aspects of the climate system. Using those tools to really smartly advance the state-of-the-art I think will help with the error bar problem, which is a significant challenge going forward. But we should be able to give communities a real edge in understanding what's likely to be visiting them not just today but—

Mr. FROST. Yes.

Dr. BUDIL [continuing]. Several years down the road.

Mr. FROST. Thank you so much. I have more questions, but I've run out of time. I really appreciate your time today and excited to work with this Committee on advancing our economy and national security by investing in the green energy economy. I really appreciate it.

Mr. BABIN. I'd like to recognize the gentleman from Ohio, Mr. Miller.

Mr. MILLER. Thank you, Mr. Chairman. I just want to say thank you to Chairman Lucas and Ranking Member Lofgren for holding this important hearing. And thank you to our witnesses for your insight today.

I don't think there's more of an appropriate topic for this Committee to address through its first hearing of Congress. The Chinese Communist Party is the United States' greatest threat on the world stage. It is critical that we remain a global leader in cutting-edge science and advanced technologies to address this threat and to ensure our economic and national security for generations to come.

One issue I'd like to focus on today is the need for a skilled workforce as a key component of our strategic competition with China. Roughly 36 million jobs in the United States today are part of the STEM workforce. That is nearly 1/4 of all jobs nationally. In these 36 million jobs, 17 million of them are filled by skilled technical workers who have a wealth of science, engineering, and technical knowledge but do not hold 4-year degrees. Clearly, there is a need for career and technical education programs that equip workers with much-needed skills without saddling them with unmanageable debt. A more robust approach to career and technical education will ensure that we are able to train workers properly and remain competitive with China, which has made efforts to recruit top foreign talent, including from American universities, industry, and government.

Dr. Droegemeier, you put it simply in your testimony. It boils down to people. As part of this, you propose an initiative similar to the GI Bill to coordinate workforce development on a national scale with broad national goals that involve all sectors of the Science and Technology Enterprise. Can you elaborate on the need for Federal involvement in a coordinated approach to STEM workforce development programs that we have here?

Dr. DROEGEMEIER. Congressman, thank you so much. I loved your comments there, and you're spot on. We have a lot of great programs that are going on. I think at last count there were well over 150 STEM education programs, some large, some small. There are a lot of nonprofits doing great things. And like I said earlier, there's like a thousand flowers blooming, but where are the big gardens?

If you look at the GI Bill, it really had two pieces to it. One was to thank the servicemen and women who were responsible for the Allied victory in World War II coming back from World War II. And the other thing was, they're an important part of our future, so let's make sure we invest in them. So my thought about something—a GI Bill-type activity here would be to say we need to coordinate much more effectively vis-à-vis the National S&T Strategy, which gives us the chance to do something we've never done before, really, I think, to look at this from a holistic national point of view, to create really what I would call not a U.S. talent program but a U.S.—sort of a capabilities investment program to bring people to the fore whether they're in—looking at a skilled technical workforce or whatever, to create a framework that has basically a system that has them, you know, being educated and trained, but then also giving service back to our Nation, which is—in fact, the GI Bill, the service came on the front end. This would come on the back end actually. I don't think it ought to be a hand-out. It ought to not not be a freebie, but it ought to be structured like the GI Bill to where part of that was loans to start companies, part of it was tuition, and so on.

I think getting folks into the game from all over America is so critically important. And, as I think Deborah said, you know, we're fielding a baseball team with one player. This gets a chance for all these folks who—I've seen capabilities all over this country in the places you would least expect to find them. We need to get those missing millions. We need to go find them. We need to bring them

in. And we need to incentivize and provide them resources to be successful, but then say, you know what, you owe a debt of gratitude to our Nation. Here's the service component of that. And we build on American exceptionalism, I think, in doing so.

Mr. MILLER. Yes, I could not agree more with your assessment.

Ms. Wince-Smith, you also raise the issue of regional diversity within the innovation economy as part of the National Science and Technology Strategy. In your testimony, you highlighted the fact that the innovation workforce is concentrated largely in metropolitan areas such as Boston, San Francisco, San Jose, Seattle, and San Diego. You also wrote one-size-fits-all approaches to supporting regional innovation ignore these crucial and geographic distinctions and fail to capitalize on different regions, core competencies, and advantages.

As someone who represents a middle America district in northeast Ohio, I sympathize with this view. I want to see jobs pop up in Cleveland, Parma, Medina, Wooster, Strongsville, and other communities in our area, not just in big coastal cities. So do you think that regional centers dedicated to completing—excuse me—complementing the existing capabilities and resources of a specific area would result in organic pipeline for workforce development?

Ms. WINCE-SMITH. Thank you for that wonderful question. And I have to say I'm from Akron.

Mr. MILLER. Oh, nice.

Ms. WINCE-SMITH. So I know the region very well.

Mr. MILLER. You're right there.

Ms. WINCE-SMITH. And I know, of course, that Toledo was, as I said, the inventor of one of the flat panel displays, and, you know, for solar, et cetera.

I think that this is really a regional leadership issue. I think that what happens often in States and regions that all these dots are not connected. The workforce development boards do not collaborate with the economic development boards. You have to bring in sort of the leaders of the community. And you can see the power of a leader in a community. I'll just cite San Diego. You know, San Diego still is a great center of our U.S. Navy, but it's become a leader in wireless communications and biotech because of how they brought all that together and one startup Linkabit that became Qualcomm. So leadership is very, very critical for this.

And also the educational establishment from K through 12 all the way up, including, you know, leaders who are doing our sports activity. We put so much time and effort in developing talent for people going into sports but we don't do the same for them going into STEM. I mean, it would be great to have a cybersecurity corps. But on the regional economic development I'm seeing across the country, and the U.S. Council on Competitiveness is so focused on this, just tremendous capability that's not even known. And so the National Science Foundation, you know, the other departments are really making an effort to go out and identify through these hubs and investments how they can create an anchor and then build for this.

And then of course the issue is on capital. Venture capital, you know, for certain types of things is great, but it's concentrated. But still in all these regions there are some high-net-worth individuals

who are doing things. Nebraska is a fabulous example of that. So we have all the ingredients——

Mr. ISSA [presiding]. Would the gentlelady wrap up, please?

Ms. WINCE-SMITH. We have all the ingredients.

Mr. MILLER. Thank you, Mr. Chair. I yield back my time.

Mr. ISSA. Thank you. Even though you're from Akron and I'm from Cleveland, the gentleman is from Cleveland, we're—we have to call it quits on that.

We now recognize the gentleman from California, Mr. Mullin.

Mr. MULLIN. Thank you, Mr. Chair. And thank you to our witnesses for your testimony.

I come from San Mateo County in the San Francisco Bay Area, home to some innovative partnerships. I really appreciate the community college references as well, retraining with community colleges and our local workforce development boards and our life sciences sector, which is a very robust one.

So my question is a bit of a follow up, Dr. Droegemeier. You were talking about the national STEM strategy and GI Bill approach, but you did reference supplanting some existing programs. And I just want to get a sort of sense, you know, the existing *Workforce Investment Act* funding streams and there's money in *CHIPS* now, investments in *IRA (Inflation Reduction Act)* on clean energy. How do you pull all of these things together into a coordinated funding approach where there's some coherence but you're also integrating—I say this as a former local workforce investment board member who always appreciated dealing with some of those Federal funding streams coming down to the local level, how we integrate all of that in a coordinated way.

Dr. DROEGEMEIER. You said it so beautifully, and it's that whole-of-nation approach. I think that those local boards play an extremely important role, and their voice needs to be at the table. So I think it's a question of scaling up, and in no way do I suggest that a lot of these programs aren't doing good things or whatever. But I think the—what you created with the National S&T Strategy is an opportunity to step way back from all the wonderful individual things and say what do we do as a nation and how do we coordinate it? How do we not—it's not about control, but it's about coordination and scaling and having a symbiosis among all of these different programs to where we're looking to achieve national goals, not, hey, my little program is doing this, and it's doing great things, but how is it feeding the national goal of workforce development, of economic development, of diversity enhancement? That's the thing that I think you have wonderfully handed to OSTP and the community and said you guys go figure this out. And that's what I am looking forward to doing. And I really appreciate you doing that because it's never really happened before.

Mr. MULLIN. Thank you for that. Just a quick follow up on scale, well aware of large companies being able to operate at scale and innovate and develop STEM partnerships, but a lot of the innovation is happening in smaller companies. You know, we're talking, you know, five people in the R&D space doing incredible work. How do we—as we think going forward, how do we develop an S&T strategy that really integrates some of those smaller companies? Just any thoughts in that regard I'd welcome.

Dr. BUDIL. So I'll chime in since I brought this up earlier. I think this is an excellent question. I think part of it is creating mechanisms to give people access to the tools and capabilities they need to continue their progress. So, for example, if you're a small company developing hard technology, the barriers to entry in the market are enormous. Just the cost of building capacity to do the R&D you need to advance your technology. And this national look can say, OK, what could a regional center do to develop central capabilities that many companies could have access to for advanced machining capabilities or different types of laboratory facilities or access to high-performance computing, and then using existing institutions, academic institutions or national laboratories or others, to help bring expertise to these companies to help them advance their capabilities quickly? I think it's really a new kind of partnership ecosystem where we really try to think about all the national assets and how we can bring them together in new ways.

Dr. DROEGEMEIER. Could I just follow up on that last point? A lot of small businesses, as you say, can't afford wet labs, clean rooms, things like that. But universities have these things. And believe me, they're not busy all the time. And so now you can—private companies can go in and legally use these facilities by paying for them. The university is not competing unfairly with the private sector by undercutting them because they're nonprofit. These partnerships are so important. And this is where you can also build wonderful linkages for R&D with universities. But it might just start with sharing a facility that you need to have to fabricate the device or something as a small startup. But they're incredibly agile and they're wonderful and they're the bedrock of our economy.

Mr. MULLIN. Thank you for that. I yield back.

Mr. ISSA. Thank the gentleman. And I'll yield myself for a round of questioning.

One of the nice things about going last is that everyone else has asked questions, probably asked every question, they just haven't been asked by me. So I'm going to stick to pretty much two questions. One is a recap. Ms. Smith and others can weigh in on this. But, you know, when talking about the centers of excellence and talking about trying to reach out all over the country—and by the way, as a Clevelander, I'm very proud of Case Western as a university of excellence. But I'm a San Diegan, so I'm even more proud of the University of California, San Diego, and very aware of what Stanford represented to the building of Silicon Valley.

At the end of the day, aren't our universities in many, many cases the reason—not the size of a city because San Jose was a pretty hick town when they got going. But aren't—isn't it not about the size but in fact the excellence of the universities, and that those are naturally places that, within the technology UC Davis, you know, for agriculture and a lot of their areas of expertise? Isn't that what we need to look for and recognize? You can't make every university a center of excellence, but every great university eventually creates a field of interest and excellence.

Ms. WINCE-SMITH. Thank you. Thank you, Congressman. You said it very, very well. The universities and our whole network across the country, our crown jewel, no country in the world has the scale of universities, the—from community colleges all the way

up to the most advanced research institutes in the world. And if you look throughout the country, yes, universities are anchoring, and they have the great potential to do more.

Mr. ISSA. So as we as a Committee—and we don't—we're not the Committee that funds every university, but as we look at plans and we look at supporting a national plan—I was in Bozeman, Montana, for example. Now, they know more about wheat and barley and, by the way, the beer it makes, and they have just an amazing amount of technology there that I wouldn't have known if I hadn't gone there on a congressional trip. But shouldn't we, as a Congress, look to the Administration to have a plan that maps the world mostly as it is from the standpoint of university expertise, not grant writing, as we would hope it would become, which often works to the detriment of do you really go to Bozeman, Montana, to do nuclear fusion? Any—is that consistent with all of your thoughts?

Ms. WINCE-SMITH. I think we need to do both. And I think we have the capacity to do both. We want to continue——

Mr. ISSA. We're out of money, ma'am, so in fairness——

Ms. WINCE-SMITH. Well——

Mr. ISSA [continuing]. Let's be a little careful about that. We have massive debts. We're at a deficit that's unbelievable, so the idea that there's enough money to do everything we want to do versus using our money wisely is going to be an area that I know the Chairman is very concerned about is how to get the best return for the taxpayer on those dollars that are already being spent? Because it's unlikely that we're going to dramatically increase dollars spent in this environment.

Ms. WINCE-SMITH. And that wasn't what I was suggesting. What I was suggesting is, whatever the area we want to work in, let's link together these universities with partnerships because there are other places of the country doing the advance work in agriculture. And just because they don't happen to be in Montana, they should be working together. So knitting these things together is absolutely the key to building up this infrastructure for the country in the future.

Mr. ISSA. Excellent. I agree.

Last one is one that's near and dear to my heart, even though I'm a native Clevelander and a Californian now. China does not respect intellectual property, and yet China is one of the greatest recipients of patents both directly and indirectly, directly in the sense that they have tremendous amount of applications that basically go back to the CCP, indirectly because they are making acquisitions and inquiries and they have investment funds that essentially rake intellectual property out of the United States and take it back to China. Well, in fact, as a recipient of a Chinese patent, I know it's as worthless as the paper it was printed on. Should this Committee look to the question and other Committees, including Judiciary, look to the question of reciprocal activity, meaning should we continue to have China dealt with like a trusted partner? Should universities be free to share with mainland China, as they do, massive amounts of the work that the taxpayer pays for? Or should we have a plan to recognize that they are not an evenhanded competitor? Your comments?

Ms. WINCE-SMITH. Well, I'll just jump in on that. I do think we need reciprocity, and I think we need new models and mechanisms. For instance, one of the things we could do is if we identify stolen intellectual property that comes into any product that's entered into this country, we refuse its entry. We do this—we have a wonderful system for protecting the integrity of our food supply and agricultural products coming in but we don't on intellectual property. And, you know, I serve on the Commission for the Theft of American Intellectual Property, and they have some fabulous recommendations. But by the time we get through the process of identifying the impact of what's been stolen, often the company's out of business. So it is an absolutely critical crisis for the country.

And just one metric, back in 2012 there was the data if China implemented their existing intellectual property laws, however weak they are, we would have had \$1.2 trillion more in GDP (gross domestic product). And that was in the first report of the Commission on the Theft of Intellectual Property.

Mr. ISSA. Thank you. My time has expired.

The gentleman from—the gentlewoman from Michigan, Ms. Stevens.

Ms. STEVENS. Thank you. It's quite interesting thinking about competition from the standpoint of American debt. I just can't imagine that the CCP is doing that. And while some are debating the integrity, the fiscal integrity of this Nation by threatening to default America on its debt, I can't imagine a bigger vote in this chamber being one for our competitor countries than our own country.

But with that, look, we were very pleased in a bipartisan way to pass the *CHIPS and Science Act*, much legislation that came through this Committee, legislation I was happy to author, and certainly recognizing that some of our colleagues who were more reticent to join onto legislation bolstering and investing in scientific research for the first time ever because they woke up to the threat and the competition with the CCP.

And so as we think about the *CHIPS and Science Act* and some of our great catching up that we have been doing with that legislation, the first Federal funding opportunity coming out just yesterday, I'm interested in honing in on other technologies or R&D areas that we need to be investing in that we might not be thinking of. Dr. Budil, you had talked about supercomputing. We remember that race. Ms. Wince-Smith, we certainly have been collaborating for years on supercomputer technology and its benefits. But what other research applications should we be looking at?

Dr. BUDIL. So I can begin? That's an excellent question. I think the whole computing ecosystem is incredibly important. It's another great area where public-private partnerships have really spurred the development of high-performance computing at scale, which has enabled new kinds of science we didn't envision when we started down that path. So again, ensuring that we stay closely coupled to industry trends. Industry isn't going to build computers just for science because that's a very small market relative to what they typically are focused on. So ensuring that the scientific community and the industry that builds machines are very closely coupled together and can advance and can take advantage of the new

tools that are coming along in AI and machine learning and then looking at advanced technologies like quantum, neuromorphic computing, and other approaches that will really change the game for how we think about R&D.

Another area that's critically important is—that we've talked about a great deal here today is energy technologies. That includes new technologies, for example, for long-term storage or batteries, other clean energy technologies in the future, could be fusion energy technology, but taking U.S. leadership in some of these areas and really capitalizing on it. I think advanced materials and manufacturing is another area where investment is really critical. That industry is changing very, very fast, and the nexus of high-performance computing and manufacturing capabilities is going to change the game again. So in the next 10 years, you'll see something very different.

And then the final one is biotechnology and biosciences. Barriers to entry in these fields are very low. They're moving very fast. And we have an opportunity with our capabilities, experimental and computational, to really foundationally change the speed and capacity of how we think about development of drugs and therapeutics, how we think about disease, and how we think about the technologies that will enable us to better understand biological systems.

Ms. STEVENS. Ms. Wince-Smith, did you want to chime in? Are policymakers listening and acting accordingly?

Ms. WINCE-SMITH. It's hard to add to what Dr. Budil has said, but I would just mention biofabrication also as part of the biotechnology revolution.

Ms. STEVENS. And certainly to the point about how we effectively utilize the taxpayer dollar for outcomes, for proven outcomes, public-private partnerships, which you've mentioned several times in this hearing, tend to work. Are there any specific examples you'd like to point to that have been successful that we could build off of as a nation?

Dr. BUDIL. I'll point to my favorite recent example. There was a partnership formed called ATOM, Accelerating Therapeutic Opportunities in Medicine. It was a partnership that started between a discussion between the National Cancer Institute and the Department of Energy. It included GlaxoSmithKline, Lawrence Livermore National Lab, and University of California, San Francisco, so very unique public-private partnership, bringing together biosciences, clinical research, Big Pharma, and the Federal stakeholders that were key there. And the goal was to develop tools to use computational methods to very rapidly screen molecules for drug applications. So if you could take the drug development timeline from 10 years down to less than 1 year, it would make it much more economically feasible for companies to develop new molecules.

For GSK it wasn't about, "what can I do. It was about can I create a toolkit that allows my whole industry to move ahead?" So from that perspective, they wanted to bring other companies into that partnership. I think that sort of precompetitive landscape is a really novel feature and was uniquely enabling of what we were able to do there.

Ms. STEVENS. Thank you. With that I'm out of time. I yield back, Mr. Chair.

Mr. ISSA. Thank you.

We now recognize the gentleman from California, Mr. McCormick.

Mr. MCCORMICK. Good morning. Money is power, especially when it comes to technology, developing technology, is one of the most expensive things we do in the world. In 2019, I believe we had about \$2.4 trillion of investment in R&D and technologies. The United States roughly had about \$722 billion of that. But over the course of time, from the sixties up to 2020, we've gone from about 69 percent of the research done in the world to about 31 percent, so less than half of what we used to do percentagewise. This goes back to monetary policy. I'm concerned when it comes to technological advances between us and China, in a nation that has anywhere from roughly \$20 trillion more debt than we do and a smaller GDP, that they're basically held unaccountable while they buy our debt. And they don't have the same central banking system accountability. I'm concerned that we're being outpaced. We have no way to keep up in a fair market. Nobody's holding them accountable. Meanwhile, you discussed how important it is to have people in foreign status come to our schools and work in our universities.

I worked at—I taught at Georgia Tech and Morehouse for about 4 years. Georgia Tech is a leading school in the Nation in technologies. And yet, we can have a Chinese student come over here and actually take their technology back there while they're spending trillions of dollars more on research and development. I just don't see how we win that battle because it's not a fair fight. How do we combat that?

Dr. DROEGEMEIER. Well, it's a key question I think ultimately here in terms of—one extreme is you lock everything down and you protect everything. That's not the answer. The other thing is you let it all be open. That's not the answer either. When you're looking at fundamental research, curiosity-driven research, a lot of people say, well, it gets published anyway, so what does it matter? Well, it matters because the pathway of doing that work and getting to the publication involves a lot of creativity, a lot of knowhow that is very valuable. And it doesn't make its way into the publication. Publication is just the end result. So what we're trying to protect is the capability, the knowhow, the sort of secret sauce that we have in our research laboratories like at Georgia Tech that results in the publications. I think, again, it's really a question of educating people, having policies in place at universities in particular, having resources that universities can turn to to understand and vet individual—

Mr. MCCORMICK. I'm going to interrupt you real quick because we're almost at two and a half minutes.

Dr. DROEGEMEIER. Yes, yes, sure.

Mr. MCCORMICK. Specifically what I'm worried about—

Dr. DROEGEMEIER. Yes.

Mr. MCCORMICK [continuing]. Is give me a specific example of those controls. I know we have that policy, but I don't know of them—and I'll tell you, when I was at Georgia Tech, we had people go to jail, because of espionage, because of Chinese foreigners com-

ing and stealing our secrets. And we spend about half of the R&D budget that goes to universities comes from our government, which in 2019 was about \$40 billion of investment and then everybody else investing another \$50 billion. So my question is, what are we specifically doing to safeguard those technologies?

Dr. DROEGEMEIER. Well, again, I think we're educating people to look for certain behaviors, right? We're asking people to disclose relationships, which is a self-disclosure. And then—but here's the key. We can use open-source analytics to determine if they're being honest because it's all just based on, OK, if they say what they're—they're telling us who they really work with or who they're affiliated with, great. If they don't, well, we have no way of knowing.

Mr. MCCORMICK. OK. So if they're coming here from China, they're affiliated with China. They're getting an education and going back to China with what—their education they're getting here that we put trillions of dollars into.

Dr. DROEGEMEIER. Right. But they're also benefiting our universities. We're learning from—and 90 percent of those people are staying here. They're not going back. And so they're yearning for freedom. They don't have the freedom to discover and create in China. The talent programs in China, frankly, are not working. They're failing. Because all this repatriation of talent, they're not getting the folks coming back. Where—we still lead in that area, but it's a precarious lead, so you're right.

Mr. MCCORMICK. I'd make the point, too, that of the 90 percent, the people who stay here in the United States, we should probably be keeping a pretty close eye on them because there's significant links back to the place where they come from, including the family that remains in place.

Dr. DROEGEMEIER. Yes, exactly. And a lot of pressure is put on them by the Chinese Government to report behaviors, to report people who are their colleagues, students, are you saying bad things about China? Are you supporting Taiwan? There are considerable pressures being brought to bear on those individuals. So in some sense, we want to help them deal with that. But ultimately, it's the Chinese Communist Party that is the villain here, not the Federal Government trying to protect our capabilities, as you say, to make sure that we become and remain a global leader.

Mr. MCCORMICK. Right. And with that, I have about 24 seconds. I'm supposing that nobody has the monetary policy acumen to answer what we're doing to address the inconsistencies of the Chinese central banking system and its advantages over us.

Ms. WINCE-SMITH. I'll just add another topic for a future time is how they're doing debt financing of infrastructure all over the world and what that means, too.

Mr. MCCORMICK. Exactly related. Thank you.

Mr. ISSA. I thank the gentleman. We now recognize the gentleman from Illinois, Mr. Sorensen.

Mr. SORENSEN. Thank you, Mr. Chairman, and good afternoon. My name is Eric Sorensen. I was born and raised in Rockford, Illinois, and attended Northern Illinois University, where I studied communications and meteorology. I served my communities as a meteorologist from 1999 to 2021. My job was to help my community by sharing the best information about upcoming severe weather

and our changing climate. When people have access to accurate weather forecasts and climate data, we know that they make good decisions about their personal safety and about their own future. So I want to extend a special welcome to my fellow meteorologist on the panel, Dr. Droegemeier, for being here. And I do want to very quickly thank my colleagues in Oklahoma for safely keeping people ahead of the storms in the past 24 to 36 hours. They saved lives, and that's the power of meteorology.

I'm thrilled to join not only this Committee, but become the first meteorologist in Congress in nearly half a century. Today, I would like to focus on the structure of the U.S. approach to science and technology, how our approach really differs from that of other countries, including China, and how we can use these differences to our advantage.

So I'll start with our meteorologist, esteemed Dr. Droegemeier. Research institutions at our Nation's universities like in my district, Monmouth College and Augustana College, provide critical S&T research, much does OU. This type of research is often built upon the private industry developing these new advanced technologies and investments. The private industries building on the advanced technology often develop in geographical proximity to the university that developed the basic technology. This relationship benefits the community and the economy around the university.

So my question, how do we ensure that private companies that utilize the freeform nature of S&T R&D located around the producing university, thus giving back to the community that produced the technology?

Dr. DROEGEMEIER. Well, thank you so much for your good question and for your kind remarks there. We do a lot of this at OU. In fact, we have companies locating on our campus. And how do you incentivize them to stay there? And a lot of times they'll develop—I started a private company and it got purchased, but it's still, you know, in Norman. I think the key thing is to make sure you lower the barrier to entry to interact with the university in terms of if they're on the campus, you provide space for them at rates that do not undercut what they could get in the community but in fact are commensurate. But the value of being there is perhaps sort of comarketing of being able to go to seminars, getting access to students, having students work in your company, and so on. As you're developing the technology, the university kind of becomes your R&D arm.

So if you're a small business, you don't have an R&D component, your company will, hey, the university could do that. And it doesn't necessarily require you to have a funded research relationship with the university. It might be that you're serving on a graduate student's committee and you deconflict yourself, you don't have a conflict of interest, but you're providing a private-sector perspective on the work that they're doing. And you might involve them doing an internship in your company for maybe not a lot of money, but all of a sudden, then you're able to hire them, because you've vetted them. You know exactly their capabilities. You've developed their capabilities. Now, all of a sudden, they're your employee, and so you've not made a huge investment in them. You've reaped the benefits of being at the university.

That's, I think, the power of the local economic development. I think the key thing is to have the university not see itself in competition with the local economic development authorities. You want to have a partnership to where we say the university plays an important role. The Chamber of Commerce plays an important role. A lot of times there's economic development organizations that play a role. We at—in Oklahoma in Norman, we have a triumvirate of those things, and they all work together. If somebody comes to the campus, great. If they don't come to campus, great. If they're in Norman or they're nearby, we call that a win. So it's about, I think, being a good partner in this and not wanting to have everything for yourself but growing with the community in mind, as you say.

Mr. SORENSEN. My district consists of rural parts of western Illinois, smaller suburban areas. We know that smaller universities tend to attract much less funding. We have to make sure that more funding gets to smaller schools. What policies can Congress install to ensure that a diverse set of universities get their funding, their piece of that funding pie? I'll give this to anyone.

Dr. DROEGEMEIER. Well, I'll just tell you one thing that NSF is doing, it's got a new program called GRANTED, it stands for, if I get this right, Growing Research Access for Nationally Transformative Equity and Diversity. And the idea basically is to say that small universities, small colleges, they they have the capability to compete in terms of personnel, but they don't have the administrative structures to manage grants, to do proposal submissions, to meet all the compliance rules and regulations. So the idea is that if we as a Federal Government could invest in that capability through helping build partnerships with other institutions, then we empower them to unleash the capabilities of their faculty without putting them in jeopardy of getting an audit report on a grant that they somehow mismanaged without any ill intent. But they simply didn't have the people who knew what they were doing, and they weren't used to doing it. They didn't have a history. So that kind of program, which is not super expensive, it's leveraging the existing capabilities at R1 and R2 schools to build an ecosystem of partnerships of administering grant proposals and grant awards once they're funded. That will really empower a lot of institutions.

Mr. SORENSEN. Thank you. I'm out of time. I yield back.

Mr. ISSA. We now recognize the gentlelady from New York, Ms. Tenney.

Ms. TENNEY. Thank you, Chairman Issa and the Ranking Member, for holding this important meeting on U.S.-China competitiveness, and thank you to the witnesses for your time and insight, looking forward to hearing from you.

New York's new 24th congressional District has a history as the home to the Erie Canal, which is one of the first regions in our country to enter and successfully prosper during the Industrial Revolution. However, unfortunately, in upstate New York, and it's particular in my region along the canal, we've suffered tremendously as we've allowed China to flood our markets with cheap, subsidized products. We've lost jobs, we've lost companies. So many have been displaced, so many iconic names that people would recognize such as Oneida, such as IBM and other big contributors.

But over the last few decades, the rise of the malign influence of the Chinese Communist Party harmed Americans as it was—it stated—its State-sponsored espionage efforts have stolen American intellectual property. I believe it's over \$600 billion now on an annual basis. And its unfair trade tactics have driven American industries out of business. Additionally, China continues to spread its greater economic position to spread its techno-authoritarian model abroad, all across the world actually.

While the Federal Government invests heavily in research and development, private businesses must roughly invest three times as much annually into research and development. To stay at the forefront of new emerging industries, the Federal Government must ensure its effort complements those in the private sector and not hurts them. This can be achieved through rewarding organizations with a good track record of successfully commercializing technologies, and through proven policies, including the R&D tax credit.

I want to first direct my first question to Ms. Wince-Smith. So in your testimony that was given, you discussed the troubling concentration of science and technology investments in coastal hubs like Silicon Valley. This leaves large swaths of our country and important industries such as manufacturing without access to the capital they need to innovate and thrive, particularly where I am from. So my first question for you is, from your perspective, how can we leverage the national science and technology plan to geographically diversify investments in science and technology and bring them to our rural regions, particularly upstate New York, which gets often forgotten between Buffalo and New York City.

Ms. WINCE-SMITH. Thank you, Congresswoman. Well, we've had some discussion on that. And I know your region very well. And one thing I would say is the extent to which in our large-scale partnerships that we have funded by NSF, Department of Energy, we might think of having some kind of a provision where we're talking about diversity, equity, and inclusion of people and talent, but we ought to think of that also geographically so that every big project would also reach out and include an institution from a different part of the country that would have some compatible resources.

I'll give you another example. And Dr. Budil could really talk to this better than I. But I know when Kodak had its difficulties—

Ms. TENNEY. Um-hum.

Ms. WINCE-SMITH [continuing]. In Rochester, the whole optics workforce they had, the best in the world, many of those people came to Livermore to build NIF. So the mobility we have of people is one thing, but at the end of the day, it's really creating the environment for companies that want to come and invest there and also grow. I mean, I know Micron just has a new facility in New York that they've come in. And maybe also, you know, the old idea of incentives, tax breaks and things is a little outdated, but there are other types of incentives that states and regions can give for locating in their facilities and the trained talent used for that.

Ms. TENNEY. But wouldn't you agree that incentives would be better than having sort of mandates and set-asides and—

Ms. WINCE-SMITH. Oh, yes. Yes.

Ms. TENNEY. Because you got me concerned when you mentioned DEI and the fact that we have a State that's very hostile to businesses and incentivizing. That's why we don't have Kodak, Bausch and Lomb, Xerox, all those—all from the Rochester region, you know, have left for better tax treatment, better opportunities, and access to capital actually.

So let me ask you, so you—in your “Competing in the Next Economy” report, you talk about the importance of breathing life in declining U.S. regional economies by stemming the brain drain, injecting high skills, and raising innovation potential. Can you tell me specifically not including a DEI-type scenario that you would—how do you address those in our rural communities? We have wonderful people who work—farmers, people who've been displaced because of the growing difficulty in, you know, for example, farming in upstate New York, even though my district is the No. 1 dairy and egg district in the entire Northeast, but we need help. How would you do that in—

Ms. WINCE-SMITH. Well, I first want to clarify, when I was talking about diversity, equity, inclusion, I was specifically meaning geographical and regional, that we have all regions of the country included, and there are ways, you know, to do that.

In terms of the work of the Council on Competitiveness, what we're going to be doing is anchoring a lot of this with universities in the regions, community colleges, 4-year college and on, and have them be kind of the anchor and helping to develop this with workforce boards and economic development agencies and also identify the leadership networks in these regions. You know, there's a lot of wealth still in that part of New York. Are they investing? Are they supporting startups and things? So we're going to look at these—I mean, there's a lot of knowledge to learn because we—nobody has the recipe for this yet. If we did, we wouldn't be having this conversation. But it's an imperative.

Ms. TENNEY. If I may, for 1 minute, Mr. Chairman, we have—

Mr. ISSA. Very, very quickly.

Ms. TENNEY. We do have the highest taxes in the Nation, not California anymore, so that's a big problem, which is why I do support the tax incentives, especially in places like New York where there really is no place to get relief other than the Federal side. But we appreciate your comments. I acknowledge my time's run out. Thank you.

Mr. ISSA. Thank you. We now recognize the gentlelady from North Carolina, Mrs. Foushee.

Mrs. FOUSHEE. Thank you, Mr. Chairman, and thank all of you for being here today. This topic is particularly relevant to North Carolina's 4th Congressional District, which is home to several federally funded research centers and projects, including the Triangle University's Nuclear Laboratory, the North Carolina Biotechnology Center, North Carolina Central University's Biomanufacturing Research Institute and Technology Enterprise known as BRITE, and the UNC (University of North Carolina) Collaborative Sciences Center for Road Safety, just to name a few, and additionally, our world-class research universities and the Research Triangle Park, a premier global innovation center and the Nation's largest research park, home to nearly 400 companies and over 60,000 em-

ployees. So I am particularly encouraged by the promise that our region holds for innovation and in enhancing our Nation's global competitiveness in science and technology.

Today, I would like to talk with you about how we can leverage our Nation's regional strengths, given our success so far throughout North Carolina, as an example of what can be achieved when we bring together local and State governments with corporate, non-profit, and university partners.

So my first question is for Dr. Droegemeier and Ms. Wince-Smith. In your provided testimonies, you mentioned the importance of regional innovation and partnerships, a key component included in the *CHIPS and Science Act*. And I'm wondering if you can briefly highlight the opportunities and some possible challenges facing regional innovation.

Dr. DROEGEMEIER. You've said it so beautifully in terms of the importance of regional partnerships and with Research Triangle Park and Research Triangle Institute and the extraordinary resources you have there, still, North Carolina is a rural State, right, and there's a lot of folks in North Carolina that need to be brought brought to the table.

Partnerships take a lot of different forms, and the reason you do partnerships is really because you need help in doing something that you can't do on your own, frankly. And there's probably another reason where you say you want to lift up others who basically have been disadvantaged for a variety of reasons or whatever.

When I was at the White House, I realized through a variety of meetings we had that, although a lot of Federal agencies have partnership offices, we don't really do partnerships very well, and people were realizing, oh, we could do much better. I think that's true for universities, it's true for basically all the sort of key players in a state, that they have their own swim lanes, as Deborah said earlier, but the economic development folks don't talk to the workforce development folks. And it seems so surprising and so simple. But getting them together and looking at the broad plan is really the key thing.

And I think what the National S&T Strategy provides an opportunity to do is to have that conversation and confront the difficult challenge that we have of not knowing what all we have and not knowing who's not talking to who. And it's not really the government's job to do the work. It's the government's job to bring the people together. And frankly, I think the private sector is better positioned than the government to structure those—I'm not saying in terms of OSTP, but I'm saying in terms of having software and capabilities to bring people together, to find these creative differences, to find the folks that aren't in the game, to how do we get them to the table. That really is the key in my view of building these partnerships and creating the broader community that will uplift the rural communities that have so much to offer but they're just not in the game now because they don't have the resources. And that's what this plan, if we do it right, I think will give us the roadmap for how to do it. And I know Deborah, I'm sure, has some thoughts.

Ms. WINCE-SMITH. I would just add, Congresswoman, that North Carolina is a poster child of success. And many parts of the country

look at North Carolina how—you know, that whole Research Triangle Park, the great universities, the economy developed.

And one thing also on the leadership issue, were very inspired active Governors. I remember some years ago working with Governor Hunt, and that was kind of his focus. And another example going on right now is in Tennessee where the Governor is working very, very closely with Oak Ridge National Lab, with both—all the universities, including the smaller ones and community colleges, and the new companies that are beginning to look at that area as a center place for battery manufacturing in the EV (electric vehicle) revolution.

Mr. ISSA. Yield back?

Mrs. FOUSHEE. I do.

Mr. ISSA. Thank you. We now go to the gentleman from New York, Mr. Williams.

Mr. WILLIAMS. Thank you, Mr. Chairman.

I just have hopefully very short questions. Dr. Budil in particular, I look forward to supporting you in your fusion work, near and dear to my heart. Just one question, though. Is there any public investment that you believe would yield fusion on the grid by 2032 in the time—in a 10-year timeframe?

Dr. BUDIL. Thank you for your support, and thank you for the question. It really is true that the sort of X axis, how long till fusion energy on the grid is a function of investment, that's public investment as well as private investment, and which technology path you pursue. So there are significant efforts on magnetic fusion and growing efforts in inertial confinement fusion energy approaches today. It's a little bit early days for us to say whether there's a plan that will get you there in 10 years, but it's certainly true that the level of investment would need to be significantly larger to galvanize that kind of effort. There's a lot of intellectual capital that's interested in pursuing this. Students are really energized by fusion prospects. There's a lot of private capital on the table. And unfortunately, the investment in fusion energy demonstration is still early days.

Mr. WILLIAMS. Should we be making policy decisions about our energy mix, anticipating, expecting, planning, and depending on fusion on the grid by 2032?

Dr. BUDIL. I think you always have to plan for the future energy mix with what we would characterize as an uncertainty band because there are a whole host of technologies that could contribute that are varying degrees of maturity. And so I would—certainly wouldn't put all my eggs in any one basket. There are technologies that are mature today that can contribute to a sustainable energy mix in 10 years, and there are nascent technologies like fusion that have the potential, although the next few years will be critical to determine what that timeline really looks like. So I'm a fan of all of the above, really trying to think about all the tools we have in our toolkit to ensure the U.S. has a sustainable, economically viable energy sector.

Mr. WILLIAMS. Thank you. Ms. Wince-Smith, you mentioned dual-use technologies. Do you mind clarifying, if you were to provide a definition of dual use, what comes to your mind?

Ms. WINCE-SMITH. From the very inception, they have both commercial and military applications. And increasingly, all the technologies we've been talking about in this hearing that are reshaping the world have that. You know, Putin said some years ago, whoever controls and leads in AI will control the world. She has given the list of these. And, you know, you see—I mean, I should mention this example. You know, we've talked about university research and the Chinese. One of the major universities in Australia, one of the centers of quantum work had four Chinese researchers who all turned out to be from the PLA (People's Liberation Army)——

Mr. WILLIAMS. If I may, I just——

Ms. WINCE-SMITH [continuing]. Who has a serious issue on dual use.

Mr. WILLIAMS. I'll be advancing a letter to other Members to prioritize DOE spending in research in particular for dual-use technologies. We have to meet our civilian commitments, but there's things like uranium enrichment, tritium production upon which fusion relies that also have military use, and so that—we should prioritize those. Thank you.

Dr. Kelvin, just because that's easier to pronounce, I apologize. So my mother went to OU for a year, and my uncle was—got his Ph.D. there in civil engineering and was a professor there in Norman, you know, years ago. There's a few things in your comments—in your opening comments. Do you think we need a 20-year plan similar to China's for our national technology policy?

Dr. DROEGEMEIER. Well, I think that the 4-year timeline for the S&T Strategy is good. Four, 5 years seems right. I don't know that I'd call it a 25-year plan or 20-year plan, but I'd say we need a 25-year lookahead or a 20-year lookahead within—to set the context for that 5-year plan.

Mr. WILLIAMS. Thank you. Should government direct industry involvement like China—sorry, industry investment like China? Should our government be having the same kind of heavy hand that China has in directing investment?

Dr. DROEGEMEIER. No, I don't believe so.

Mr. WILLIAMS. Would you say that our American system is inherently uncompetitive relative to the Chinese model?

Dr. DROEGEMEIER. For me?

Mr. WILLIAMS. Yes.

Dr. DROEGEMEIER. No, I would say it's highly competitive because of our freedoms to create and so on. As we heard earlier, China does most of its work in applied R&D, and they're basically reaping the benefits of our investments in fundamental research. They're improving their fundamental research, but that's really the seed corn of everything that follows. So I think we're very innovative. I think we're very competitive, but we have to maintain our competitive position.

Mr. WILLIAMS. Thank you. I yield back.

Mr. ISSA. Thank you. We now recognize the gentlelady from Colorado, Ms. Caraveo.

Ms. CARAVEO. Thank you, Chairman Lucas and Ranking Member Bonamici, for today's hearing, my first Science Committee hearing

ever, and it looks like I might be closing it out. To our panel of witnesses, thank you so much for joining us.

You know, our science agencies do a wonderful job of partnering with academic scientists to generate scientific discoveries and, importantly, to help train the next generation of STEM students. In my district, for example, the National Institute of Standards and Technology has a partnership with the University of Colorado at Boulder that places undergraduates, graduate students, and postdoctoral researchers in Federal labs to gain important hands-on experience alongside NIST scientists. I know that the *CHIPS and Science Act* help broaden opportunities such as these at many of our science agencies, but I think that there's still more that we can do.

So Dr. Budil, can you talk about your experiences with university partnerships at Lawrence Livermore National Lab and the importance of partnerships between national labs and universities to expand STEM opportunities?

Dr. BUDIL. Yes, thank you very much for the question. Our partnerships with academic institutions are essential. They really are the lifeblood of our laboratory. And they bring new ideas, new people, new energy, new enthusiasm into our environment every day. And I would say I think about partnerships with universities across the full spectrum. So we work with community college partners, we work with 4-year universities, we work with large R1 universities, we work locally, and we work across the U.S. with a wide variety of institutions, institutions that have specific skills and focus disciplinary research in areas that are really important to us.

So we try to do several things in those partnerships. We try to build enduring relationships with faculty members who have important expertise or research lines. We teach them about our work. We give them access to our facilities. We work in close partnership with them, so it's not a one-and-done transactional, send me your student, and—those research partnerships really keep that connective tissue alive between us and these many institutions.

And then we work to bring a wide variety of students across many disciplines into our environment, both on an enduring basis—we have many students who do, for example, their Ph.D. research at the laboratory. But large-scale summer programs are particularly important where students get to come and spend several months, as you said, working in a real laboratory or with real computational specialists and understanding what it means to be a scientist.

We also do outreach at earlier ages to really introduce younger students, high school age and younger, to what science looks like and how much fun science is. And I really do love seeing my early career staff in particular go out into these institutions and the joy they bring, the commitment they have to our important missions and the research that we do, but the gift it is to be able to work in these disciplines really advancing the state-of-the-art. So university partnerships are foundational to everything we do.

Ms. CARAVEO. Yes, coming from medicine, I know how important it is for workforce development to have hands-on experience, so thank you very much for those programs that you run.

Dr. Droegemeier, in your testimony, you discuss the need to coordinate workforce development on a national scale. What opportunities do you think exist to leverage Federal labs and university partnerships to get more STEM-capable students into the workforce? And how can the National Science and Technology Strategy leverage these partnerships?

Dr. DROEGEMEIER. Well, thank you so much for the question. I think it's absolutely vital because those are existing like the 17 DOE national labs, which are absolutely our crown jewel, and all the NOAA laboratories and NIST laboratories that you have in Boulder, they are exceptionally capable. They have wonderful people, researchers, so on. We need to leverage what we already have. And when we do that, we're actually getting a one-plus-one-equals-five kind of proposition versus building a lot of new stuff. By linking existing, quote, stuff together, we can get a—really a multiplicative factor.

And if I can come back to the point that Dr. Budil made—and you're a health person—in Boulder and also in Oklahoma, what we did was we took a page out of the playbook of medicine. We said if you bring together operational people, you bring together research and education like the teaching hospital concept, you've got all three together to leverage one another. You've got Federal operations folks, you've got Federal researchers, you got academic researchers, you got the education piece. It works well in the teaching hospital, and Boulder did that and we did it and it works well. Now, it's—you know, it's not replicable everywhere because there aren't necessarily Federal operations, but there is a lot of them out there. And if you think of that model as being another model for partnerships, it's something we could really leverage in the S&T strategy.

Ms. CARAVEO. Thank you both so much. I yield back my time.

Mr. WILLIAMS [presiding]. Thank you.

The Chair recognizes the gentleman from New Jersey, Mr. Kean for 5 minutes.

Mr. KEAN. Thank you, Mr. Chairman. And thank you to the panel for being here today and helping educate us on the issues facing this country and this Committee.

I come from the 7th Congressional District in New Jersey. I would argue it's the most innovative district in the country between life sciences, information technology, manufacturing, many other thought leaders. Many other countries, Ms. Wince-Smith, have introduced more tax and other incentive policies, including modeling their technology transfer policies after those in the United States. How important is it that we continue to foster continued public-private partnerships? And what are some of the areas where the United States leads the world and that we cannot afford to lose?

Ms. WINCE-SMITH. Thank you, Congressman, for that question. I think our public-private partnerships are absolutely essential. And I think it also goes to the character of our Nation that we have always been a people that sees opportunities by working outside of our comfort zone, as it were. We've seen that since we were pioneers in coming to this country, so it's essential. And, quite frankly, our technology transfer legislation that goes back to the 1980s and

the Bayh-Dole, and all—those acts, and they're regulatory acts that were implemented by Congress, have played a huge role in helping us to commercialize technology with the private sector. And I will say in my work, countries around the world are always coming and wanting to study, how do you do these partnerships? They know about them, but they really don't know the secret sauce of what goes into it. And I think we've all been talking about that during the day.

So I think it's very exciting, yes, with limited resources but huge opportunities, that we leverage them because we're not going to get ahead and advance semiconductors beyond Moore's law or the battery futures, the biotech, the frontiers, you know, in your State without these public-private partnerships that involve business, academia, our national labs, and our workforce, including labor. So they are absolutely essential.

Mr. KEAN. And I agree with you in that regard in the State, and then there's Federal policy in both areas to create—so really the creative ecosystem for that. But what should we be doing to improve those relationships?

Ms. WINCE-SMITH. Well, I think one of the ways to improve those relationships is always to understand the transparency that's involved in them and also that the partners have sometimes different priorities and different time horizons. You know, an academic researcher has a much longer timeframe work than someone working at a national lab that has a development component and a mission. And then of course, business, they really are operating under, you know, quarterly earnings, investors who say if you don't have your product out there, we're finished with you. So how you meld all those together to advance is not trivial, and that's a challenge, I think, to continue to work on.

Mr. KEAN. Thank you. Thank you to you and to the panel. I yield back my time.

Mr. WILLIAMS. You know, a change in the geopolitical picture in just the last 30 days has really transformed the importance and significance of your expertise and testimony. And the—not only the questioning but the answers that you provided could in fact have historical importance in the years and decades to come. So I really want to thank each one of you for your exceptional expertise and contribution. It's personally near and dear to me. I've spent much of the last 18 years in innovation working with tech transfer offices in my career in the nuclear Navy, which was very short. But it's—I really do value and appreciate all your different perspectives.

So I thank you for your time. I thank also my colleagues and Members for their questions. The record will remain open for 10 days for additional written comments and written questions from Members. And this hearing is adjourned.

[Whereupon, at 12:39 p.m., the Committee was adjourned.]

## Appendix

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### ANSWERS TO POST-HEARING QUESTIONS

## ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Kelvin Droegemeier

**U.S. HOUSE OF REPRESENTATIVES  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**

*“The United States, China and the Fight for Global Leadership: Building a U.S. National Science and Technology Strategy”*

Dr. Kelvin Droegemeier, Regents’ Professor of Meteorology and Weathernews, Chair Emeritus Roger and Sherry Teigen Presidential Professor, University of Oklahoma and Former Director, White House Office of Science and Technology Policy

Questions Submitted by Chairman Frank Lucas, Committee on Science, Space, and Technology

1. The Committee heard the importance of taking a long-term approach to the National S&T Strategy. China takes a similarly long-term view to its strategic investment in science. You often hear that “we won’t beat China by becoming China”. What can we learn from China’s long-term plan to S&T, and what negative consequences might arise from simply replicating China’s approach to S&T investments?

*I absolutely agree that the U.S. won’t beat China by becoming China, but we can learn a few things from how China operates that do not conflict with our values. In particular, as I mentioned in my oral and written testimony, I believe the U.S. strategy for S&T global leadership should take a much longer view than the next budget cycle, the next election, or even a quadrennial assessment and five-year S&T Strategy. All of those things of course are extremely important, but I believe the U.S. would be well disposed to conduct its strategic planning within the context of a much longer view – say a 25-year horizon that addresses not specific technologies to be pursued or research challenges to be tackled, but rather broader contours of what it will take to be a global leader.*

*For example, the creation of major international alliances with like-minded partners and establishing a science and technology counterpart to the G7; new and innovative frameworks for bringing disparate sectors together to collaborate and increase the rapidity with which research outcomes are translated into practical products and services (PCAST released a report on this in January, 2021); a national, long-term plan for international STEM students and researchers studying and staying in the U.S. with appropriate safeguards to our research enterprise; a vision for the role of the U.S. in major research facilities and leveraging its vast array of National and Federal Laboratories in ways that provide much greater added value; and a bold vision for growing domestic STEM talent and recapturing activities, such as manufacturing, which have gone overseas and which now provide great leverage by adversaries against us.*

*These long-term, guiding aspirations to maximize research capabilities can be underpinned by shorter assessments and strategies created with the principles laid out in my written testimony (e.g., bold and transformative, completely bipartisan, engaging all sectors of the R&D enterprise, and not playing to not lose).*

2. You briefly mentioned in your testimony that, "...the U.S. must maintain its global leadership position in Science and Technology...by leading with its values." Can you talk a little bit more about what you meant by that?

*Many things differentiate the U.S. from China, but in my view, none more so than the fundamental values that underpin their respective approaches to governance and treatment of people. In the U.S., those values are enshrined in the Constitution and fundamentally involve a broad array of freedoms. In the context of your question, they include the freedom to discover and create; the freedom to debate, challenge, and speak freely; the freedom to share; a free market system to transition research outcomes into practice for the benefit of humanity; and the freedom for individuals to pursue their own pathways and dreams.*

*Most researchers inherently want freedom of action to perform their work, and this is one of the many reasons the U.S. remains the destination of choice for foreign scholars. In its new report<sup>1</sup> about research engagement with China, MIT lays out a number of lines it is unwilling to cross, and I believe they capture the importance of leading with values. They include "not engage[ing] in collaborative activities that could compromise the integrity or objectivity of our academic work," "not accommodate[ing] attempts by prospective collaborators, sponsors or donors – whether domestic or international – to exclude certain MIT individuals from participation...", "not engaging in collaborations... that might help China, or other governments, use advanced technologies against the United States," "not engage[ing] in research collaborations that might contribute to human rights abuses or other actions by the government of China (or other governments) against its own people," and "be cautious about engaging in collaborations in which our engagement might legitimize or indirectly promote actions by the Chinese government (or other governments) that conflict with the core values of the MIT community."*

*As you can see, values of integrity, objectivity, non-discrimination, and respect of human rights – among many – are foundational to distinguishing the U.S. from the Chinese government. Consequently, in leading with its values for global leadership in S&T, the U.S. speaks with an unmistakable voice and gives researchers a clear choice about the sort of environment in which they will operate – a choice most researchers will have no difficulty making.*

3. In your testimony you proposed that the NSTS should run institutional experiments such as academic-corporate partnerships in which specific regulations are temporarily suspended or streamlined as a proof-of-concept, with the outcomes used to implement broader change. What are the biggest regulatory hurdles to accelerating technological and scientific innovation that should be prioritized in such experiments?

*I especially appreciate the opportunity to answer this important question because experimentation should not be confined to the conduct of research itself, but also be pursued in research policy and administration – and boldly so. As an example, the extraordinary urgency associated with the COVID pandemic spurred a great deal of creativity and innovation – in both research and policy – that otherwise would not have*

<sup>1</sup> <https://orgchart.mit.edu/sites/default/files/reports/20221116-AssociateProvost-University-Engagement-with-China-final.pdf>

*occurred. Regulations were streamlined, funding for research was made available quickly, new programs were created without the traditional months of debate usually required, partnerships were formed with amazing speed and effectiveness, and assets were pre-positioned. Might it be the case that some of these actions, which addressed regulations and procedures that either were unnecessary or unnecessarily complicated, could be made permanent? The way to find out is to conduct an experiment – with a sense of urgency driven not by a global crisis, but rather principally by the importance of global leadership. The experiment would test the application of creative ideas, in a structured and controlled manner, for lowering or removing administrative policy hurdles that are known to hamper research progress.*

*Such an experiment could involve a few R&D funding agencies (e.g., NSF, NASA, DOE) on selected topics of fundamental and applied research. Many of the most significant hurdles could be overcome by doing the following, some of which might require special, temporary Executive Office of the President authority or OMB/OIRA regulatory suspension for the duration of the experiment.*

- a. Brief research proposals (5 pages plus budget) with rapid (4 week maximum) review.*
- b. Complete flexibility in moving funding among categories in the approved award budget with only institutional (not funding agency) approval required.*
- c. Abbreviated yearly progress reports to the agency in the form of five PowerPoint slides (e.g., progress compared with goals; challenges encountered; unexpected opportunities pursued; funding summary; next steps in the project).*
- d. Highly simplified time and effort reporting structure at the institutional level.*
- e. Highly streamlined and rapid turnaround protocol reviews (e.g., IRB, IACUC for human subjects and animal research, respectively).*
- f. A simple partnering agreement for engaging private sector companies that lays out clear intellectual property (IP) provisions. IP is an important sticking point in academic-corporate collaborations, and the goal of the experiment would not be to overturn existing paradigms, but rather to evaluate how, for certain types of projects, a rapid agreement could accelerate research progress.*
- g. Involving in the experiment venture capitalists and other stakeholders who would see the work progress from its inception and, as appropriate, be ready to step in with funding to move research outcomes across the “valley of death” (i.e., the transition stage from research prototype to commercially viable product or service). This pre-positioning of capital and early stakeholder engagement could greatly accelerate the translation of research outcomes to practicable benefits for society in appropriate circumstances.*

*The overall experiment should be thoughtfully designed, engaging relevant Federal funding agencies via the National Science and Technology Council, as well as external organizations such as academic professional societies, the Council on Governmental*

*Relations (COGR), and the Federal Demonstration Partnership (FDP). The overall program should be assessed by professional evaluators throughout experiment execution.*

*Although the points enumerated above might serve as a starting point for ideation, I would suggest directing OSTP to convene relevant stakeholders, including OMB, to scaffold the program, using lessons learned from the COVID pandemic to identify specific actions to accelerate research progress. OSTP is not structured to oversee the experiment, so that issue would need to be considered as well.*

Questions submitted by Rep. Emilia Sykes, Member, Committee on Science, Space, and Technology

1. Can you briefly discuss why it's important that as we go about implementing the CHIPS and Science Act that we maintain that robust funding for those newly authorized programs? What could happen to our ability to compete with China long-term if we fail to do so?

*When it comes to competition with China, the numbers are against us. China has far more people, graduates far more students from universities, and is increasing the quality of its research and publications rapidly, and in significant ways. According to the National Science Foundation, based upon data from 1990 – 2017,<sup>2</sup> “China continues to exhibit the world’s most dramatic R&D growth trend” in gross domestic expenditures in current purchasing power parity dollars.<sup>3</sup> It notes “The pace of China’s increase in R&D performance has been exceptionally high for numerous years, averaging 20.5% annually over 2000–10 and 12.8% for 2010–17.” That China is becoming a greater contributor to the global science and technology enterprise is in most respects a positive development, and sheer numbers are part of the reason.*

*Yet, many examples exist throughout history – from biblical times to the present – which clearly demonstrate that numbers alone are not the deciding factor in global leadership. But they do matter. And thus, one thing is certain: If the U.S. fails to invest substantially, predictably, and strategically in fundamental research – which represents the foundation of most innovation, a major dimension of economic and national security, the work that gave rise to many of the transformative products and services we enjoy today, and one of the things China covets and needs most – then the U.S. will further cede global R&D leadership to China. That is not an acceptable outcome.*

*Although the U.S. perhaps cannot outspend or outsize China, we can out-innovate China, as in in the past; with appropriate care collaborate with China; and importantly, lead globally with our values. But we have to plan and invest. The CHIPS and Science Act has*

<sup>2</sup> <https://nces.nsf.gov/pubs/nsb20203/figure/4-7>

<sup>3</sup> According to the Organization of Economic Cooperation and Development ([oecd.org/sdd/purchasingpowerparities-frequentlyaskedquestionsfaq.htm#FAQ1](https://oecd.org/sdd/purchasingpowerparities-frequentlyaskedquestionsfaq.htm#FAQ1)), “PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including GDP.”

*given us that opportunity. Yet, as one profound example, the failure by Congress to fund the National Science Foundation base budget at authorized levels – and instead provide a sizeable but one-time supplemental increase – was a significant missed opportunity. NSF now is straining to meet the many requirements of the authorization and obviously cannot do so for the long term with year-to-year supplements. Although it is true the U.S. has an amazing ability to do more with less, the research community, and especially NSF, are running out of less.*

*The simple answer to your question is that, without robust and predictable funding for the newly-authorized programs in the CHIPS plus Science Act – especially in support of fundamental research, strengthening a diverse STEM-capable workforce, and building the newly established NSF Directorate for Technology, Innovation and Partnerships – the U.S. will continue to lose ground to China – ground that will be difficult if not impossible to recapture. And as we well realize, the stakes today are higher than ever before.*

*Responses by Ms. Deborah Wince-Smith*  
**U.S. HOUSE OF REPRESENTATIVES**  
**COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**

*“The United States, China and the Fight for Global Leadership: Building a U.S. National Science and Technology Strategy”*

Ms. Deborah Wince-Smith, President and CEO, Council on Competitiveness

Questions Submitted by Chairman Frank Lucas, Committee on Science, Space, and Technology

1. The Committee heard the importance of taking a long-term approach to the National S&T Strategy. China takes a similarly long-term view to its strategic investment in science. You often hear that “we won’t beat China by becoming China”. What can we learn from China’s long-term plan to S&T, and what negative consequences might arise from simply replicating China’s approach to S&T investments?

*There’s no question that the U.S. would benefit from longer term, more stable S&T investments. The importance of sustained increases in federal research and development funding has been widely documented as critical to U.S. competitiveness. It enables stability in longer term projects that are often the sole purview of the federal government (private sector research being short term and more commercially focused). It ensure funding availability for new and upcoming researchers constantly injecting to ideas and energy into the U.S. research enterprise.*

*But, the key difference between the top down Chinese approach and the more entrepreneurial U.S. approach is in our ability to be strategic without being proscriptive. We do not pick companies or specific technologies – we identify challenges and let the marketplace of ideas and American ingenuity tackle them. That could be the future of quantum, fusion energy, AI, cyber security, etc., but how we get there is not something to be dictated from Washington. America’s creativity and freedom of thought is a competitive asset that can’t be overstated.*

2. In your testimony you cited a myriad of ways China has unfairly acquired US technology, including building research centers in U.S. innovation hubs, partnering with U.S. research universities, and sending students to the United States for academic studies. Can you talk about some ways we in Congress can help make the science and technology ecosystem more resilient to Chinese efforts to recruit our best and brightest?

*Quite simply, we must do a better job of encouraging and supporting U.S. students pursuing STEM degrees at the undergraduate and graduate levels. That could mean financial support and something as ensuring slots at U.S. universities are made available to qualified U.S. students. Further, as we look to provide educational opportunities for foreign students, we should consider prioritizing students from those countries who are allies and partners around the world.*

3. In your testimony you suggest the National S&T Strategy should include the establishment of regional centers dedicated to innovation fields that compliment the existing expertise, capabilities, and natural resources of a specific area. Based on your experience, what impact do you think this would have on U.S. manufacturing capabilities and cost? Do you think this system will result in an organic pipeline for workforce development and education?

*Building on my answer above, the Council has long held (going back to its early days working on clusters of innovation) that regional innovation supports national competitiveness. We take for granted today that Atlanta is a logistics hub, Research Triangle is a biotech hub, San Diego is a military/marine hub, but this was not always the case and is often overlooked when people talk about successful regional strategies. It's not all about Silicon Valley. None of these areas are any different than a hundred other potential innovation regions around the country. What is needed is exactly what we are seeing happening today with the availability of seed funding to encourage local/regional coordination between government, academia, and business; and a commitment to leveraging local resources and strengths to create an atmosphere of innovation that encourages students to stay after graduation, entrepreneurs to create and commercialize, and businesses to stay and expand.*

Questions submitted by Rep. Emilia Sykes, Committee on Science, Space, and Technology

1. Can you briefly discuss why it's important that as we go about implementing the CHIPS and Science Act that we maintain that robust funding for those newly-authorized programs? What could happen to our ability to compete with China long-term if we fail to do so?

*The importance of sustained increases in federal research and development funding has been widely documented as critical to U.S. competitiveness. It enables stability in longer term projects that are often the sole purview of the federal government (private sector research being short term and more commercially focused). It ensure funding availability for new and upcoming researchers constantly injecting to ideas and energy into the U.S. research enterprise.*

*Specific to the significant increases in authorized investments in the CHIPS & Science Act, as I said in my testimony, "the United States faces global challenges and competition across the scientific, research, and innovation landscapes greater than we've ever seen before. . . . In this town, and especially within the S&T community, we often refer to major challenges as being "Sputnik moments" requiring generational responses. But so often those responses while loud in the moment, fade with time and become incremental rather than game-changing. I urge you not to let that happen with the funding envisioned for science and technology in the CHIPS and Science Act."*

2. Can you briefly describe where you believe the federal government should focus its efforts to ensure high-tech manufacturing stays right here in America?

*While there are many “touch points” in the manufacturing continuum where the federal government could play a supportive role, the one area the Council has focused on in recent years has been in the ability of new firms to scale up their operations domestically. Sometime referred to as the “second valley of death”, it is at this point that firms seeking to produce in the United States must grapple with issues such as permitting, access to skilled labor, supply chain logistics, and a myriad of other challenges. The risks of a global supply chain highlighted during the pandemic created an opportunity for the U.S. to encourage more companies to produce domestically. I applaud the Congress and Administrations efforts around place-based innovation to encourage regions to leverage and coordinate their local assets in order to create the right environment for companies to be created and scale locally by looking at the total ecosystem from education to skills to regulation.*

*Responses by Dr. Kim Budil*

**U.S. HOUSE OF REPRESENTATIVES  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**

*“The United States, China and the Fight for Global Leadership: Building a U.S. National Science and Technology Strategy”*

Dr. Kim Budil, Director, Lawrence Livermore National Laboratory

Questions Submitted by Chairman Frank Lucas, Committee on Science, Space, and Technology

1. The Committee heard the importance of taking a long-term approach to the National S&T Strategy. China takes a similarly long-term view to its strategic investment in science. You often hear that “we won’t beat China by becoming China”. What can we learn from China’s long-term plan to S&T, and what negative consequences might arise from simply replicating China’s approach to S&T investments?

*I agree that we will not “beat China by becoming China.” We must build on our advantages by tapping into America’s proven pioneering spirit and seek to accelerate American innovation. In my view, the federal government can and should: (1) ensure robust funding of public sector research and development in government-unique areas; (2) facilitate public-private partnerships or other hybrid approaches where they are useful or necessary to achieve an identified outcome; and (3) incentivize tailored private-sector research and development, in cases where it may be possible and desirable for identified public policy purposes to accelerate technical progress.*

*To advance key national scientific priorities, federal resources are required to: (1) innovate - creating an art-of-the-possible that would not otherwise come into being - in order to reduce technical risk where U.S. leadership is desirable and for which commercial markets are immature; and (2) meet critical national needs where no commercial markets otherwise exist, such as development of advanced weapon systems.*

2. In your testimony you stated that public-private partnerships between our national labs, academia, and industry are critical to maintaining US S&T leadership. Are there partnership models that have worked especially well, and what can we learn from them?

*There is no one-size-fits-all partnership model; rather, partnerships should be purpose-built and draw on the scientific and technical capabilities best suited to achieving a given task. In practice, this often suggests more substantial federal investments early and more substantial private-sector investments later in the development and commercialization processes.*

*In the written testimony I submitted for the record, I provided several examples that illustrate different mechanisms: technology transfer through commercialization, consortiums, programs at the national laboratories that foster co-development with industry, and Cooperative Research and Development Agreements (CRADAs).*

- **Human Genome Project and ATOM.** *For the Human Genome Project, innovative work at three national laboratories led the Department of Energy (DOE) to undertake the task of mapping and sequencing the human genome in*

1987. The new technologies transferred to other institutions. Three years later, the DOE Human Genome Initiative joined with the National Institutes of Health and other laboratories around the world to kick off the Human Genome Project. Advances in bioscience and bioengineering led LLNL to forge the establishment in 2016 of the ATOM [Accelerating Therapeutics for Opportunities in Medicine] public-private consortium. ATOM has successfully demonstrated the feasibility of accelerated molecular design and contributed to the development of pre-clinical tools to help shorten the drug discovery timeline.

- **Advanced Supercomputing.** Sustained public investment, driven by national security needs, powered a multi-decade effort that led the United States to a place of global leadership in high-performance computing (HPC). The National Nuclear Security Administration's investment in HPC at the national laboratories and industry has led to more than a million-fold improvement in computing speed since the start of the Stockpile Stewardship Program in 1992. DOE's seven-year-long Exascale Project has supported development of the world's fastest supercomputer, located at Oak Ridge National Laboratory (and an even faster machine at LLNL later this year). Now, artificial intelligence and machine learning can dramatically enhance our ability to make advances in fields ranging from stockpile stewardship to bioscience.
  - **Extreme Ultraviolet Lithography (EUVL).** In the late 1990s, three national laboratories jointly developed EUVL, a breakthrough in chip printing technology that allowed manufacturers to print significantly smaller circuit lines and pack in more processing power. The work was funded by a three-year CRADA with industry. In 2016, a national laboratory-industry partnership further advanced EUV light sources toward the manufacturing of next generation semiconductors. It took almost two decades to incorporate EUVL into semiconductor manufacturing and produce industry-leading chips. In 2020, Apple's iPhone 12s became the first mobile phones on the market powered by 5-nm microprocessors, which are manufactured using EUVL.
3. One aspect of research security that we don't often talk about is retention of the workforce. China doesn't have to steal our intellectual property or research if they can simply buy out the talent we have here and bring them under the Chinese research enterprise. Can you talk about some ways we in Congress can help make the science and technology ecosystem more resilient to Chinese efforts to recruit our best and brightest?

*The nation needs a robust, resilient ecosystem to actively recruit and retain its next-generation STEM workforce, which requires national attention to improved STEM education. For workforce recruitment and retention, the scientific community would greatly benefit from a clearly articulated, widely supported set of technical challenges to overcome and innovation opportunities to pursue. Exciting challenges and opportunities to innovate attract the best and brightest, including top notch scientists and students from around the world. National policies and visa and immigration practices should support vital national laboratory staffing needs and engagements with the international S&T community.*

*Federal funding can help prioritize technical efforts, advance the scientific community's understanding of the universe, reduce the technical risk often associated with innovative (and especially disruptive) technologies, catalyze or incubate markets, and leverage private sector investments where possible to achieve specified public policy outcomes, national defense needs, or economic competitiveness goals.*

*Beyond targeted financial investments that develop, stabilize, and/or engage the U.S. scientific workforce, other measures should also be pursued where appropriate. In this respect, focused Congressional oversight, supportive legislative action, and/or reasonable appropriations for federal agencies with regulatory, counterintelligence, or enforcement responsibilities are critical.*

Questions submitted by Rep. Emilia Sykes, Committee on Science, Space, and Technology

1. Can you briefly discuss why it's important that as we go about implementing the CHIPS and Science Act that we maintain that robust funding for those newly authorized programs? What could happen to our ability to compete with China long-term if we fail to do so?

*The CHIPS and Science Act provides much needed funding. For the United States to remain economically vibrant and for the federal government to achieve identified policy outcomes, the government must continue to invest in priority technical areas. Failure to do so risks loss of U.S. technical leadership, creates an unnecessary weakening of American competitiveness, and potentially raises severe risks to U.S. national security.*

*China is a long-term strategic competitor to the United States and its government is investing significantly in scientific and technical areas with strategic importance. Global research and development (R&D) expenditures increased roughly threefold between 2000 and 2019. The U.S. held a 28% global share in 2019, followed by China at 22%. However, the average annual rate of increase in China's R&D spending total (10.6% over 2010-19) exceeds that of the U.S. (5.6%) and the European Union (5.6%)<sup>1</sup>. Thus, while the U.S. maintains its longstanding lead, China is well-positioned to challenge America in key technical areas.*

*China's investments are both broad-based and reflective of state priorities. In contrast, private-sector R&D spending dominates the U.S. mix. The U.S. government plays a critical role in influencing scientific and technical developments which: (1) advance a specific public need, such as national defense; (2) there is an insufficient or underdeveloped market, as with COVID vaccines and therapeutics; or (3) in areas where there is a shared public/private interest and where public resources can accelerate progress and provide the longer-term stability required to address significant R&D challenges, as with artificial intelligence or fusion energy. The CHIPS and Science Act supports the continuing role of U.S. government investment in priority technical areas is critical to sustaining American competitiveness and U.S. national security.*

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<sup>1</sup> <http://nces.nsf.gov/pubs/nsb20225>

2. Can you tell us about the contributions of our HBCU and MSI graduates, including our young women scientists, and why it's so important that they be afforded an equal opportunity to contribute?

*The 2019 National Academies report *Minority Serving Institutions - America's Underutilized Resource for Strengthening the STEM Workforce* found that "the cultural diversity of a nation's workforce is a key factor in its ability to innovate and compete in a global economy. The role of Minority Serving Institutions (MSIs) in creating a diverse STEM workforce is motivated by the realization that the United States is unlikely to maintain its competitive advantage in STEM without the contributions that these institutions are uniquely positioned to make."*

*Young professionals comprise an essential component of the nation's STEM workforce. It is important to provide opportunities and access for all who have the interest and motivation to pursue careers in STEM. A greater sense of inclusion and appreciation for how diversity enables excellence by bringing the broadest range of ideas, perspectives, and talents together, regardless of race, gender, or background, benefits everyone. Graduates of HBCUs and MSIs have many fewer role models and often have had less exposure to STEM careers or access to opportunities to build STEM skills. Now and in the future, these young scientists and engineers - and others from underrepresented groups, such as women - blaze trails in their respective fields and serve as examples of professional excellence. Their valuable contributions to science and technology inspire other students to pursue their dreams and become successful researchers, entrepreneurs, and leaders in their respective fields.*

*Lawrence Livermore National Laboratory (LLNL) has worked to strategically build relationships with MSIs in collaboration with the National Nuclear Security Administration (NNSA) and Department of Energy (DOE). These partnerships assisted the Laboratory in building a workforce pipeline, with emphasis on underrepresented groups. For example, in the last 10 years LLNL's academic engagement programs have led to the hiring of 185 postdoctoral and full-time employees—and over 125 intern hires—from MSIs. Laboratory staff have also encouraged undergraduate student interns to enroll in graduate school and have motivated students to pursue jobs in government agencies, academia, and industry.*

*To develop skills and interest in the next generation workforce, LLNL promotes a diverse and talented STEM pipeline through training and educational outreach activities that include programs aimed at graduate students, undergraduate students, STEM educators, K-12 students, and community outreach partners. LLNL collaborates with many regional schools to conduct a variety of activities including STEM events at the Laboratory, science fairs, career fairs, outreach into local schools, and teacher professional development for the most underrepresented populations in STEM fields.*

*Responses by Mr. Klon Kitchen***U.S. HOUSE OF REPRESENTATIVES  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY***“The United States, China and the Fight for Global Leadership: Building a U.S. National Science and Technology Strategy”*

Mr. Klon Kitchen, Senior Fellow, American Enterprise Institute

Questions Submitted by Chairman Frank Lucas, Committee on Science, Space, and Technology

1. The Committee heard the importance of taking a long-term approach to the National S&T Strategy. China takes a similarly long-term view to its strategic investment in science. You often hear that “we won’t beat China by becoming China”. What can we learn from China’s long-term plan to S&T, and what negative consequences might arise from simply replicating China’s approach to S&T investments?

*China's long-term approach to Science and Technology (S&T) investments has allowed it to make significant strides in various domains, including AI, telecommunications, and renewable energy. While it is essential for the U.S. to maintain a long-term S&T strategy, it's crucial to consider the differences in political systems, cultural values, and economic models. Learning from China's S&T strategy can provide valuable insights, but simply replicating their approach could lead to negative consequences, both of which are outlined below.*

*The first lesson we can draw from China's long-term plan to S&T is strategic focus; China has identified key strategic industries and technologies for development, concentrating resources and efforts on these areas. This targeted approach can help the U.S. prioritize its investments and maintain its global competitiveness. The second lesson is public-private partnerships; China effectively leverages the strengths of both the public and private sectors, creating an environment that supports innovation and commercialization. Adopting a similar model in the U.S. could help accelerate technology development and maintain a competitive edge. The third lesson is infrastructural investments; China's investments in infrastructure have created a solid foundation for S&T growth. This includes physical infrastructure like research facilities, as well as human capital and workforce development. Ensuring adequate investments in these areas can support long-term growth in the U.S. as well. Finally, we can draw from China's long-term perspective; China's long-term planning approach allows for a more stable investment environment, enabling sustained growth and development. Adopting a similar long-term perspective in the U.S. can help create a more predictable and consistent S&T funding landscape.*

*Despite these lessons, there are significant key drawbacks to simply replicating China's approach to S&T investments, including loss of intellectual property rights, authoritarian control, overemphasis on state-led innovation, and lack of transparency. China has faced criticism for its approach to intellectual property, including forced technology transfers and weak IP protection. Simply replicating China's approach could undermine the U.S.'s strong IP protection system, hindering innovation and competitiveness. China's S&T strategy is also closely aligned with the goals of its one-party political system.*

*Replicating this approach in the U.S. could erode the democratic values and freedoms that underpin American innovation and risk compromising scientific integrity. Furthermore, China's approach is highly centralized, with the government playing a dominant role in directing S&T investments. In the U.S., a more market-driven approach has historically spurred innovation. Overemphasis on state-led innovation could reduce the efficiency and creativity of the U.S. innovation ecosystem. Finally, China's lack of transparency can create an uneven playing field and hinder international cooperation. Adopting a similar approach in the U.S. could damage the nation's reputation and undermine its ability to collaborate with other countries on S&T development.*

*In summary, while the U.S. can learn valuable lessons from China's long-term approach to S&T investments, it is important to avoid simply replicating their model, which could lead to negative consequences. Instead, the U.S. should adapt the positive aspects of China's strategy within the context of its own values, political system, and innovation ecosystem to maintain its global leadership in science and technology.*

2. How do we convince our allies to take a unified approach when it comes to countering China's global influence, particularly those countries who already have agreements with the CCP or do not see China's growth as concerning?

*Convincing allies to take a unified approach in countering China's global influence requires a nuanced strategy that considers the interests, values, and concerns of each country. Here are some steps that can be taken to build a coalition of like-minded partners:*

- 1. Emphasize shared values and interests: Focus on common goals and values, such as the rule of law, human rights, and open markets, to create a sense of unity and shared purpose among allies. Encourage collaboration on initiatives that promote these values and benefit all parties involved.*
- 2. Offer economic alternatives: Many countries have agreements with China due to economic incentives, such as investment or trade opportunities. Providing alternative options for trade, investment, and infrastructure development can help reduce the reliance on China and make it easier for these countries to support a unified approach.*
- 3. Engage in multilateral diplomacy: Work through existing multilateral organizations, such as the United Nations, NATO, or regional forums like the European Union and ASEAN, to build consensus on shared concerns about China's growing influence. This approach can be more effective than bilateral diplomacy in persuading countries to adopt a unified stance.*
- 4. Foster dialogue and understanding: Encourage open communication and discussion about the potential risks and consequences of China's growing influence. Share information and analysis on China's actions and intentions to help countries better understand the implications of their engagement with China.*
- 5. Capacity building and technical assistance: Offer support to countries that may lack the resources or expertise to effectively manage their relations with China.*

*This can include assistance in negotiating fair and transparent agreements, as well as support for strengthening domestic institutions and governance.*

*6. Highlight the benefits of cooperation: Demonstrate the advantages of working together to counter China's influence, such as increased bargaining power, access to new markets, and enhanced security cooperation. Make it clear that a unified approach can lead to better outcomes for all involved.*

*7. Address legitimate concerns: Be sensitive to the concerns of countries that may be hesitant to adopt a unified approach, and work to address these issues through dialogue and diplomacy. This may involve finding compromises or offering assurances to accommodate their interests.*

*8. Lead by example: The U.S. and other like-minded nations should demonstrate their commitment to a rules-based international order and the promotion of democratic values through their own actions. This will help build credibility and trust among allies and partners.*

*By taking these steps, it is possible to build a coalition of countries that are willing to take a unified approach to countering China's global influence. This requires patience, diplomacy, and a commitment to working collaboratively with allies and partners to address shared concerns and advance common interests.*

3. In your opening statement you highlighted the importance of the American free-market system in aligning the interests of industry and government, particularly with regard to national security. How do you see that alignment of interests supporting the delicate balance between supporting basic and applied research?

*The American free-market system has played a crucial role in fostering innovation and technological advancements, while also promoting collaboration between industry and government, particularly in the realm of national security. This alignment of interests can support the delicate balance between basic and applied research in several ways, many of which build on one another: public-private partnerships, government funding and support, technology transfer and commercialization, encouraging private-sector investment, balancing risk and reward, and fostering innovation ecosystems.*

*Collaborative efforts between government and industry can lead to the sharing of resources, expertise, and insights that benefit both basic and applied research. Public-private partnerships can facilitate a more efficient and effective research ecosystem, where the government supports basic research, and the private sector focuses on applied research and commercialization. To that end, government funding for basic research is essential to ensure that foundational scientific knowledge is developed and shared widely. This creates a knowledge base that can be leveraged by the private sector to develop innovative applications and technologies. By aligning the interests of industry and government, funding can be strategically allocated to support both basic and applied research in areas of national security and economic importance.*

*The free-market system encourages the efficient transfer of technology from basic research to practical applications. This is facilitated by policies and incentives that*

*promote the sharing of knowledge and resources between academia, national laboratories, and the private sector. By aligning the interests of industry and government, it becomes easier to identify and support research that has both scientific merit and practical applications. The alignment of interests between industry and government can then lead to an environment that encourages private-sector investment in research and development. This can help fill the gap between basic and applied research, ensuring that scientific discoveries are translated into marketable products and services.*

*The free-market system allows for a more effective distribution of risks and rewards between government and industry. By aligning their interests, the government can focus on supporting high-risk, high-reward basic research that might not receive funding from the private sector, while the private sector can take on the risks associated with applied research and commercialization. Accordingly, the alignment of interests between industry and government helps to create innovation ecosystems that support both basic and applied research. These ecosystems, which include universities, national laboratories, and private companies, enable the cross-pollination of ideas and resources that can drive scientific discovery and technology development.*

*In conclusion, the alignment of interests between industry and government in the American free-market system supports the delicate balance between basic and applied research by fostering collaboration, efficiently allocating resources, and encouraging innovation. This ensures that both foundational scientific knowledge and practical applications are developed and advanced, benefiting national security, economic growth, and global competitiveness.*

Questions submitted by Rep. Emilia Sykes, Member, Committee on Science, Space, and Technology

1. Can you briefly discuss why it's important that as we go about implementing the CHIPS and Science Act that we maintain that robust funding for those newly authorized programs? What could happen to our ability to compete with China long-term if we fail to do so?

*The CHIPS (Creating Helpful Incentives to Produce Semiconductors) and Science (Securing American Innovation in Science and Engineering) Acts are designed to address critical issues in the U.S. technology sector, particularly in semiconductor manufacturing and research and development in science and engineering. Robust funding for these newly-authorized programs is essential for five main reasons: global competitiveness, economic growth, national security, research and development ecosystem, and supply chain resilience.*

*To maintain and enhance the U.S.'s position as a global technology leader, it is crucial to invest in cutting-edge research and innovation. China has been making significant investments in its own technology sector, particularly in areas like semiconductors, AI, and advanced manufacturing. Failing to match or exceed these investments could result in the U.S. falling behind in key industries, with significant economic and national security implications. The CHIPS and Science Acts aim to bolster the domestic*

*semiconductor industry and promote scientific research, which can lead to new technologies, industries, and employment opportunities. Inadequate funding could limit these positive economic outcomes. On the national security front, ensuring the U.S. has a secure and reliable supply of critical technologies—such as semiconductors—is essential for maintaining its military capabilities and protecting its interests. Failure to adequately fund these programs could compromise the nation's security and its ability to respond to emerging threats.*

*The Science Act also focuses on fostering a strong R&D ecosystem in the U.S. This ecosystem includes universities, national laboratories, and the private sector, which collectively drive innovation and create new technologies. Without sufficient funding, this ecosystem could stagnate, resulting in reduced innovation and a decline in the U.S.'s global standing in science and engineering. Finally, the CHIPS Act specifically addresses the need for a more resilient and secure semiconductor supply chain. Insufficient funding could hamper efforts to build domestic manufacturing capabilities and diversify supply chains, leaving the U.S. vulnerable to disruptions and reliant on foreign sources for essential technologies.*

*Ultimately, maintaining robust funding for the CHIPS and Science Acts is critical for ensuring the U.S.'s ability to compete with China and other global rivals in the long term. Failure to do so could have significant economic, national security, and strategic consequences, potentially diminishing the nation's global leadership in technology and innovation.*